Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Xanthate-Mediated Synthesis of (*E*)-Alkenes by Semi-Hydrogenation of Alkynes Using Water as the Hydrogen Donors

Xianglin Luo, Xiuwen Chen, Lu Chen, Kun Zhang and Yibiao Li*

Address: School of Biotechnology and Health Sciences, Wuyi University, Jiangmen, Guangdong Province, 529090, China

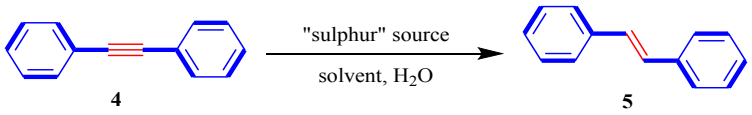
Email: Yibiao Li - leeyib268@126.com

A. General methods

Unless otherwise noted, all commercial materials and solvents were used without further purification. ^{1}H NMR spectra were recorded in $CDCl_3$ at 400 MHz (or 600 Hz) and ^{13}C NMR spectra were recorded in $CDCl_3$ at 100 MHz (or 150 Hz) respectively, ^{1}H and ^{13}C NMR were referenced to $CDCl_3$ at δ 7.260 and 77.0 respectively. The different types of carbon in the structures have been identified by HSQC, HMBC and DEPT techniques. GC–MS was obtained using electron ionization. HRMS was carried out on a MAT 95XP (Thermo). IR spectra were obtained as potassium bromide pellets or as liquid films between two potassium bromide pellets with a Brucker Vector 22 spectrometer. TLC was performed using commercially prepared 100-400 mesh silica gel plates (GF_{254}), and visualization was effected at 254 nm. All the other chemicals were purchased from Aldrich Chemicals. Commercial reagents were used without further purification.

B. Optimization of reaction conditions

Table S1. Optimization of reaction conditions[a, b]



Entry	"Sulphur" source	Solvent	Yield[b] (%)
1	-	DMF	n.r.
2	Thiourea	DMF	trace
3	Copper Dimethyldithiocarbamate	DMF	trace
4	Thioacetamide	DMF	16
5	Dimethylammonium dimethyldithiocarbamate	DMF	7
6	Sodium dimethyldithiocarbamate	DMF	32
7	**$EtOCS_2K$**	**DMF**	**98**
8	Potassium isopropyl xanthate	DMF	95
9	$EtOCS_2K$	DMSO	92
10	$EtOCS_2K$	DMAc	90
11	$EtOCS_2K$	NMP	75
12	$EtOCS_2K$	xylene	n.r.
13	$EtOCS_2K$	H_2O	< 5
14[c]	$EtOCS_2K$	DMF	31
15[d]	$EtOCS_2K$	DMF	90
16[e]	$EtOCS_2K$	DMF	85
17[f]	$EtOCS_2K$	DMF	<5
18[g]	**$EtOCS_2K$**	**DMF**	**93**
19[h]	**$EtOCS_2K$**	**DMF**	**91**

[a] Reaction conditions: alkyne **1** (1.0 mmol), "sulphur" source (2.0 mmol) in solvent (2.0 mL) and H_2O (2 mmol) for at 130 °C for 12 h; [b] Isolated Yield; [c] Reaction was carried out at 120 °C; [d] 1.5 equiv $EtOCS_2K$ was used; [e] 1.0 equiv $EtOCS_2K$ was used; [f] Anhydrous condition; [g] TEMPO (2.0 mmol) was used. [h] BHT (2.0 mmol) was used. $EtOCS_2K$ = Potassium Ethylxanthate; TEMPO = 2,2,6,6-tetramethylpiperidinooxy; BHT = 2,6-di-tert-butyl-4-methylphenol.

C. General methods for the synthesis of aryl alkenes

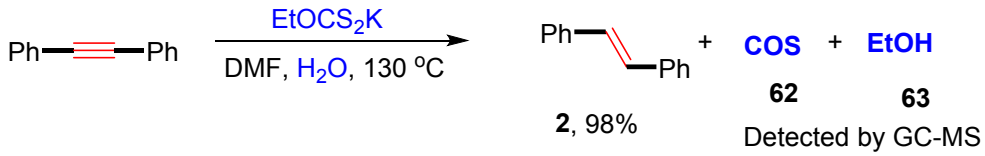
A 25 mL Schlenk tube was charged with diphenyl acetylene (178 mg, 1 mmol), $EtOCS_2K$ (320 mg, 2 mmol), DMF (2 mL) and a magnetic stirring bar. The reaction was performed for 12 h at 130 °C. After the reaction finished, the reaction mixture was diluted with ethyl acetate and passed through Celite. After evaporation of the solvent the residue was adsorbed on silica gel and the crude product was purified by column chromatography using petroleum as eluent.

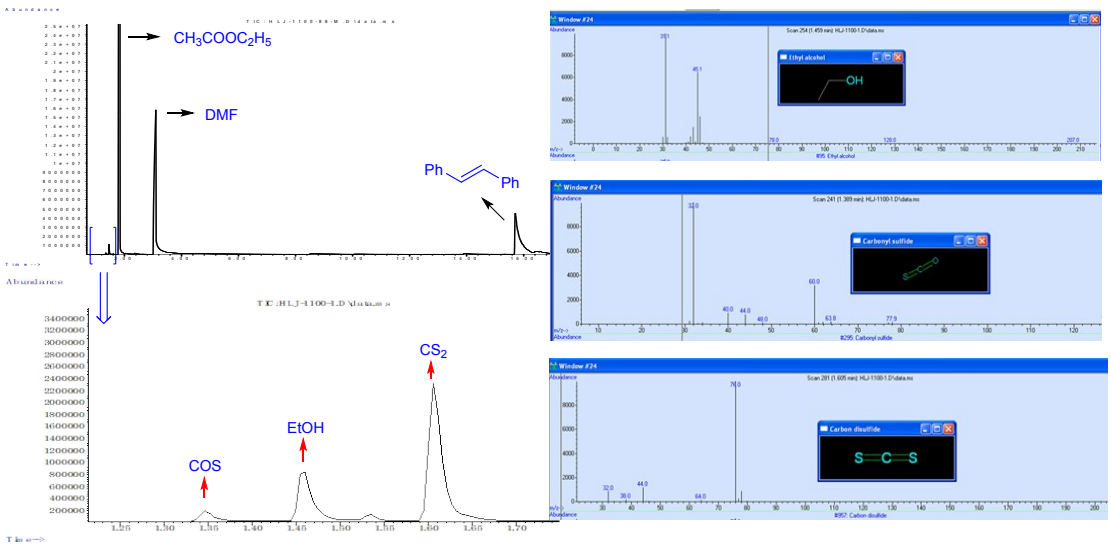
D. General methods for the synthesis of alkyl alkenes

A 25 mL Schlenk tube was charged with 2-(3,3-dimethylbut-1-yn-1-yl) pyridine (159 mg, 1 mmol), $EtOCS_2K$ (320 mg, 2 mmol), DMF (2 mL) and a magnetic stirring bar. The reaction was performed for 24 h at 150 °C. After the reaction finished, the reaction mixture was diluted with ethyl acetate and passed through Celite. After evaporation of the solvent the residue was adsorbed on silica gel and the crude product was purified by column chromatography using petroleum as eluent.

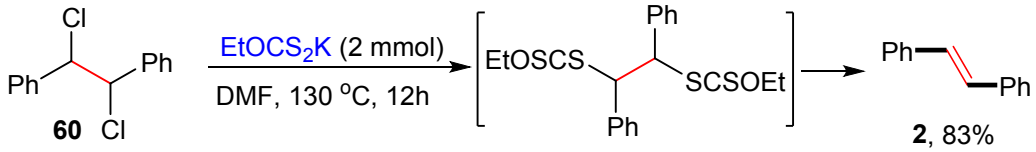
E. Control experiment

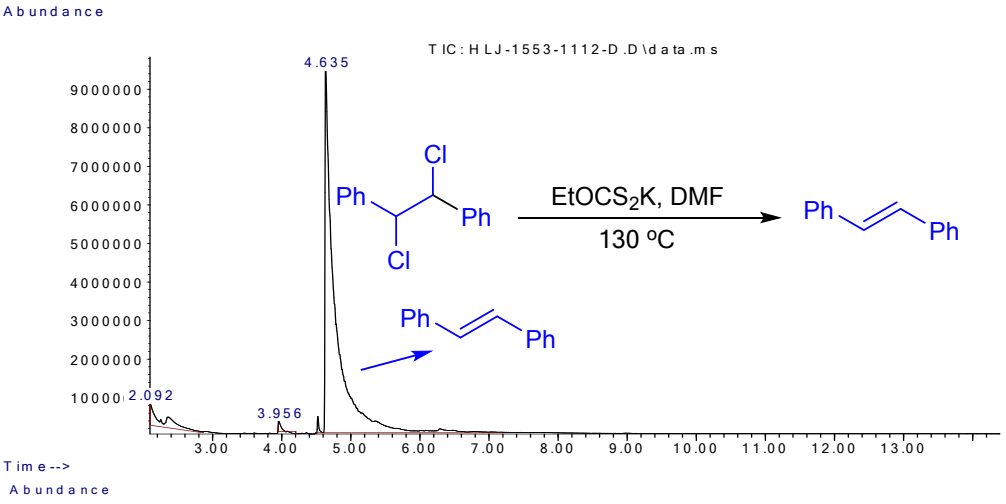
Control experiment 1 (Scheme **5e** in main text) :



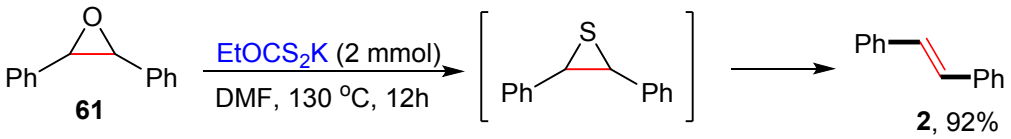


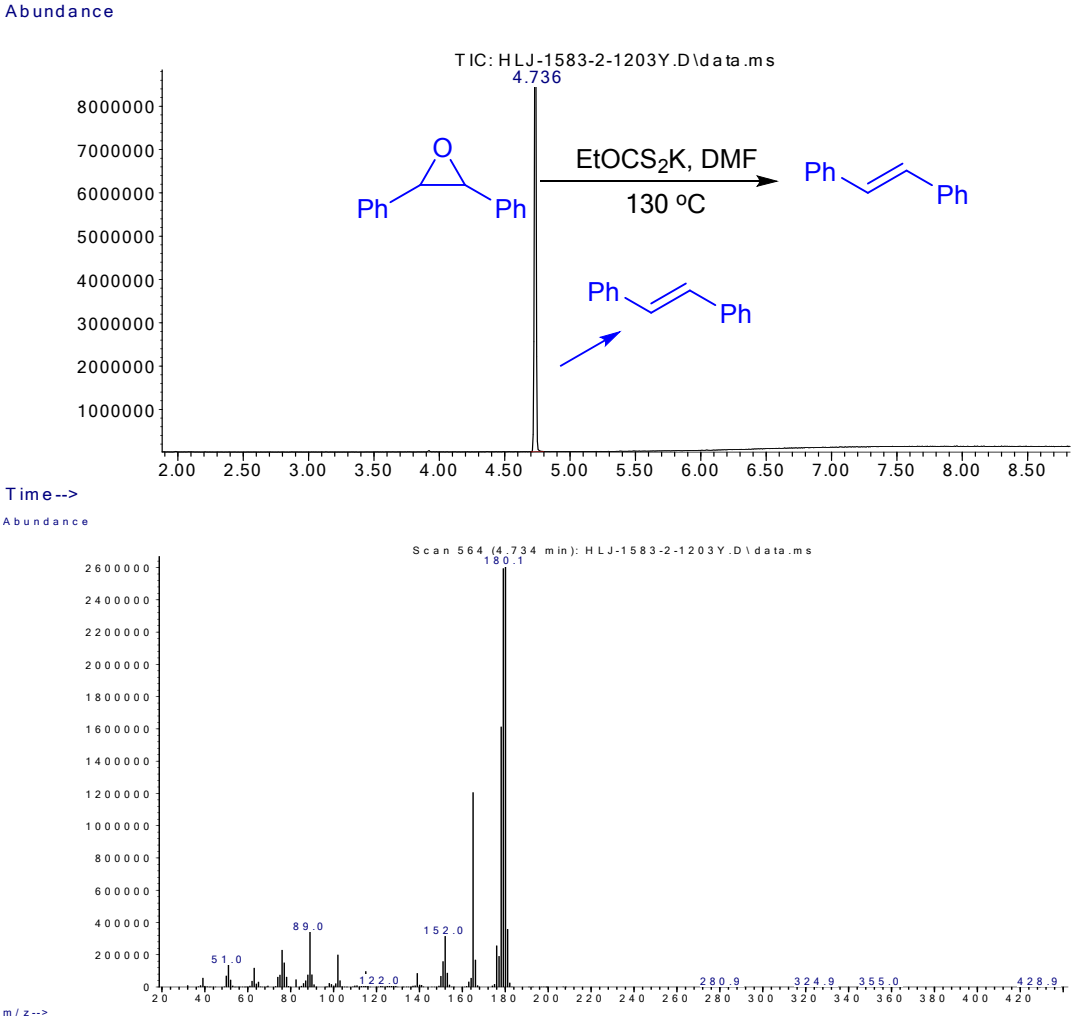
Control experiment 2 (Scheme **5c** in main text):





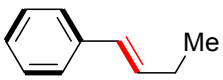
Control experiment 3 (Scheme **5d** in main text):





F. Characterization data for prepared compounds

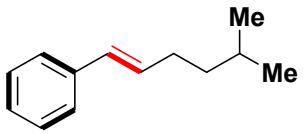
(E)-but-1-en-1-ylbenzene (**Scheme 3, 3**) [1]



White liquid (103 mg, 78% yield); R_f = 0.74 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.34 (d, *J* = 7.8 Hz, 2H), 7.29 (t, *J* = 7.5 Hz, 2H), 7.19 (t, *J* = 7.2 Hz, 1H), 6.38 (d, *J* = 16.2 Hz, 1H), 6.32 – 6.22 (m, 1H), 2.23 (dd, *J* = 14.4, 7.2 Hz, 2H), 1.09

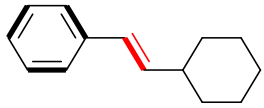
(t, J = 7.5 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 137.9, 132.6, 128.7 (2C), 128.5 (2C), 126.7, 125.9, 26.1, 13.6; GC-MS (EI, 70 eV) m/z: 132, 128, 117, 104.

(E)-(5-methylhex-1-en-1-yl) benzene (**Scheme 3, 4**) [2]



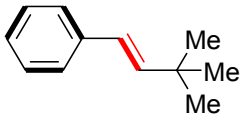
White liquid (108 mg, 62% yield); R_f = 0.74 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (t, J = 8.8 Hz, 2H), 7.30 – 7.25 (m, 2H), 7.18 (t, J = 7.0 Hz, 1H), 6.38 (d, J = 15.6 Hz, 1H), 6.22 (dt, J = 15.6, 6.8 Hz, 1H), 2.21 (dd, J = 15.2, 7.2 Hz, 2H), 1.60 (dd, J = 13.2, 6.8 Hz, 1H), 1.36 (dd, J = 15.2, 7.2 Hz, 2H), 0.96 – 0.92 (m, 3H), 0.90 (q, J = 2.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.9, 131.3, 129.5 (2C), 128.4 (2C), 126.7, 125.9, 38.5, 30.9, 27.5, 22.5 (2C); GC-MS (EI, 70 eV) m/z: 174, 131, 127, 117.

(E)-(2-cyclohexylvinyl) benzene (**Scheme 3, 5**) [3]



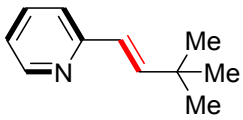
White liquid (134 mg, 72% yield); R_f = 0.65 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, J = 7.6 Hz, 2H), 7.29 (dd, J = 15.2, 7.2 Hz, 2H), 7.20 (t, J = 7.2 Hz, 1H), 6.36 (d, J = 16.0 Hz, 1H), 6.20 (dd, J = 15.6, 6.8 Hz, 1H), 2.18 – 2.10 (m, 1H), 1.78 (dd, J = 14.4, 11.2 Hz, 4H), 1.70 (d, J = 12.8 Hz, 1H), 1.37 – 1.29 (m, 2H), 1.26 – 1.16 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.0, 136.8, 128.4, 127.2(2C), 126.7 (2C), 125.9, 41.1, 32.9(2C), 26.2, 26.0(2C); GC-MS (EI, 70 eV) m/z: 186, 143, 129, 108.

(E)-(3,3-dimethylbut-1-en-1-yl) benzene (**Scheme 3, 6**)



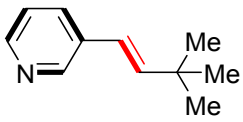
White liquid (67 mg, 42% yield); R_f = 0.78 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.38 (d, *J* = 7.2 Hz, 2H), 7.31 (dd, *J* = 7.2, 1.8 Hz, 2H), 7.20 (t, *J* = 7.2 Hz, 1H), 6.32 (d, *J* = 16.2 Hz, 1H), 6.27 (d, *J* = 16.2 Hz, 1H), 1.14 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 141.8, 138.0, 128.5 (2C), 126.7 (2C), 126.0, 124.5, 32.5, 29.6 (3C); GC-MS (EI, 70 eV) m/z: 160, 145, 128, 117; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{12}H_{17}$, 161.1325, found: 161.1323.

(E)-2-(3,3-dimethylbut-1-en-1-yl) pyridine (**Scheme 3, 8**)



Yellow liquid (142 mg, 88% yield); R_f = 0.51 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.52 (dd, *J* = 4.8, 0.6 Hz, 1H), 7.56 (td, *J* = 7.8, 1.8 Hz, 1H), 7.24 (d, *J* = 7.8 Hz, 1H), 7.05 (ddd, *J* = 7.4, 4.8, 1.0 Hz, 1H), 6.78 (d, *J* = 16.2 Hz, 1H), 6.41 (d, *J* = 16.2 Hz, 1H), 1.15 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 156.2, 149.1, 146.0, 136.2, 124.8, 121.3, 121.0, 33.3, 29.2 (3C); GC-MS (EI, 70 eV) m/z: 161, 146, 142, 131; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{11}H_{16}N$, 162.1277, found: 162.1274.

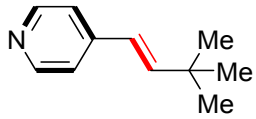
(E)-3-(3,3-dimethylbut-1-en-1-yl) pyridine (**Scheme 3, 9**)



Yellow liquid (153 mg, 95% yield); R_f = 0.54 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.52 (s, 1H), 8.36 (d, *J* = 4.2 Hz, 1H), 7.61 (d, *J* = 7.8 Hz, 1H), 7.14 (dd, *J* = 7.8, 4.8 Hz, 1H), 6.27 (d, *J* = 16.2 Hz, 1H), 6.22 (d, *J* = 16.2 Hz, 1H), 1.08 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 147.9, 147.7, 144.0, 133.4,

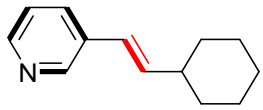
132.3, 123.2, 121.1, 33.5, 29.3(3C); GC-MS (EI, 70 eV) m/z: 161, 146, 142, 131; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{11}H_{16}N$, 162.1277, found: 162.1275.

(E)-4-(3,3-dimethylbut-1-en-1-yl) pyridine (**Scheme 3, 10**)



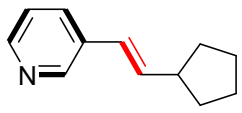
Yellow liquid (119 mg, 74% yield); R_f = 0.45 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.57 (s, 1H), 8.42 (d, *J* = 4.2 Hz, 1H), 7.67 (dt, *J* = 7.8, 7.8 Hz, 1H), 7.20 (dd, *J* = 7.8, 4.2 Hz, 1H), 6.32 (d, *J* = 16.2 Hz, 1H), 6.27 (d, *J* = 16.2Hz, 1H), 1.13 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 148.0, 147.7, 144.1, 133.5, 132.3, 123.2, 121.1, 33.5, 29.3(3C); GC-MS (EI, 70 eV) m/z: 161, 146, 131, 127; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{11}H_{16}N$, 162.1277, found: 162.1264.

(E)-3-(2-cyclohexylvinyl)pyridine (**Scheme 3, 12**)



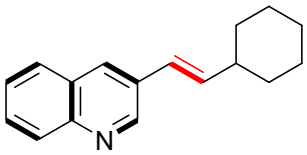
White liquid (138 mg, 74% yield); R_f = 0.55 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.54 (d, *J* = 1.2 Hz, 1H), 8.42 – 8.38 (m, 1H), 7.65 (dt, *J* = 7.8, 1.8 Hz, 1H), 7.20 (dd, *J* = 7.8, 4.8 Hz, 1H), 6.31 (d, *J* = 16.2 Hz, 1H), 6.24 (dd, *J* = 15.6, 6.6 Hz, 1H), 2.17 – 2.12 (m, 1H), 1.82 – 1.75 (m, 4H), 1.70 – 1.66 (m, 1H), 1.31 (ddd, *J* = 12.8, 8.0, 3.2 Hz, 2H), 1.21 – 1.15 (m, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 147.9, 147.7, 139.2, 133.6, 132.4, 123.7, 123.3, 41.2, 32.7 (2C), 26.06, 25.93 (2C); GC-MS (EI, 70 eV) m/z: 187, 180, 172, 158; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{13}H_{18}N$, 188.1434, found: 188.1432.

(F)-3-(2-cyclopentylvinyl)pyridine (**Scheme 3, 11**)



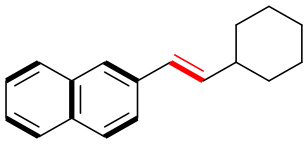
Yellow liquid (67 mg, 39% yield); R_f = 0.43 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 1H), 8.38 (d, *J* = 4.8 Hz, 1H), 7.61 (dd, *J* = 7.6, 1.2 Hz, 1H), 7.16 (dd, *J* = 8.0, 5.2 Hz, 1H), 6.31 (d, *J* = 16.0 Hz, 1H), 6.23 (dd, *J* = 16.0, 7.2 Hz, 1H), 2.61 – 2.54 (m, 1H), 1.83 (ddd, *J* = 11.0, 8.0, 3.0 Hz, 2H), 1.67 (ddd, *J* = 8.2, 6.4, 2.4 Hz, 2H), 1.62 – 1.56 (m, 2H), 1.42 – 1.33 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.9, 147.7, 138.0, 133.4, 132.3, 124.3, 123.2, 43.8, 33.0(2C), 25.1(2C); GC-MS (EI, 70 eV) m/z: 173, 158, 144, 130; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{12}H_{16}N$, 174.1277, found: 174.1276.

(E)-6-(2-cyclohexylvinyl) quinoline (**Scheme 3, 13**)



Yellow liquid (147mg, 62% yield); R_f = 0.47 (ethyl acetate/petroleum ether = 1: 5);^{1}H NMR (400 MHz, $CDCl_3$) δ 8.79 (dd, *J* = 2.4, 1.2 Hz, 1H), 8.04 – 7.96 (m, 2H), 7.78 (d, *J* = 8.8 Hz, 1H), 7.57 (s, 1H), 7.30 – 7.25 (m, 1H), 6.47 (d, *J* = 16.0 Hz, 1H), 6.37 – 6.25 (m, 1H), 2.22 – 2.10 (m, 1H), 1.86 – 1.74 (m, 4H), 1.68 (d, *J* = 12.4 Hz, 1H), 1.33 (dd, *J* = 24.8, 12.4 Hz, 2H), 1.20 (dd, *J* = 24.4, 12.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.5, 147.6, 138.3, 136.1, 135.5, 129.3, 128.4, 127.2, 126.5, 124.6, 121.1, 41.1, 32.7 (2C), 26.0 (2C), 25.9; GC-MS (EI, 70 eV) m/z: 237, 222, 208, 194.

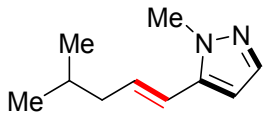
(E)-2-(2-cyclohexylvinyl)naphthalene (**Scheme 3, 7**) [3]



White solid (101 mg, 43% yield); R_f = 0.43 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (t, *J* = 8.8 Hz, 3H), 7.72 (s, 1H), 7.63 (d, *J* = 8.4 Hz, 1H), 7.51 – 7.41 (m, 2H), 6.56 (d, *J* = 16.0 Hz, 1H), 6.36 (dd, *J* = 16.0, 7.2 Hz, 1H), 2.24 (ddd, *J* = 17.8, 9.0, 5.4 Hz, 1H), 1.96 – 1.81 (m, 4H), 1.76 (d, *J* = 12.8 Hz, 1H), 1.41 (dd, *J* = 24.7, 12.3 Hz, 2H), 1.33 – 1.23 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ

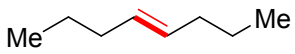
137.3, 135.6, 133.8, 132.7 (2C), 128.0, 127.8, 127.6, 127.4, 126.0, 125.3, 123.6, 41.3, 33.0(2C), 26.2, 26.1 (2C); GC-MS (EI, 70 eV) m/z: 236, 221, 193, 179.

(E)-1-methyl-5-(4-methylpent-1-en-1-yl)-1H-pyrazole (**Scheme 3, 14**)



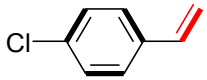
Yellow liquid (70 mg, 43% yield); R_f = 0.39 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.36 (d, *J* = 1.8 Hz, 1H), 6.27 (d, *J* = 1.8 Hz, 1H), 6.25 – 6.22 (m, 1H), 6.15 (dt, *J* = 16.2, 15.0 Hz, 1H), 3.83 (s, 3H), 2.10 (td, *J* = 7.2, 1.2 Hz, 2H), 1.72 (td, *J* = 13.2, 6.6 Hz, 1H), 0.94 (s, 3H), 0.93 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 141.0, 138.2, 134.2, 117.5, 102.2, 42.5, 36.4, 28.3, 22.3(2C); GC-MS (EI, 70 eV) m/z: 163, 149, 133, 121; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{10}H_{17}N_2$, 165.1386, found: 165.1385.

(E)-oct-4-ene (**Scheme 3, 15**) [5]



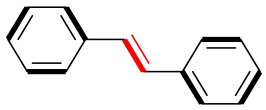
White liquid (36 mg, 32% yield); ^{1}H NMR (600 MHz, $CDCl_3$) δ 5.39 (ddd, *J* = 5.2, 3.7, 1.6 Hz, 2H), 2.00 – 1.90 (m, 4H), 1.36 (dq, *J* = 14.7, 7.4 Hz, 4H), 0.88 (t, *J* = 7.4 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 130.3 (2C), 34.7 (2C), 22.7 (2C), 13.6 (2C). GC-MS (EI, 70 eV) m/z: 112, 83, 70, 55, 41.

1-chloro-4-vinylbenzene (**Scheme 3, 16**) [6]



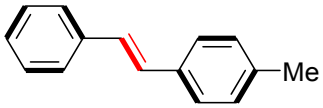
Yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.27 (m, 4H), 6.67 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.72 (d, *J* = 17.6 Hz, 1H), 5.27 (d, *J* = 10.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.1, 135.7, 133.4, 128.7 (2C), 127.4 (2C), 114.4. GC-MS (EI, 70 eV) m/z: 140, 138, 112, 103, 77.

(E)-1,2-diphenylethene (**Scheme 4, 2**) [7]



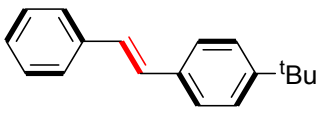
White solid (176 mg, 98% yield); R_f = 0.64 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 8.0 Hz, 4H), 7.34 (t, *J* = 7.6 Hz, 4H), 7.23 (dd, *J* = 14.0, 7.2 Hz, 2H), 7.10 (s, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.3 (2C), 128.7 (4C), 127.6 (4C), 126.5 (4C); GC-MS (EI, 70 eV) m/z: 180, 165, 152, 126.

(E)-1-methyl-4-styrylbenzene (**Scheme 4, 18**) [7]



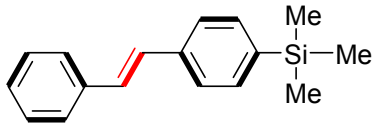
White solid (176 mg, 91% yield); R_f = 0.67 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (d, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 7.6 Hz, 2H), 7.31 – 7.22 (m, 2H), 7.18 (t, *J* = 7.2 Hz, 1H), 7.09 (d, *J* = 7.6 Hz, 2H), 6.99 (d, *J* = 18.4 Hz, 2H), 2.29 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.45, 137.36, 134.5, 129.3 (2C), 128.6(4C), 127.6 (2C), 127.3, 126.4, 126.4, 21.2 ;GC-MS (EI, 70 eV) m/z: 194, 179, 165, 115 .

(E)-1-(tert-butyl)-4-styrylbenzene (**Scheme 4, 19**)



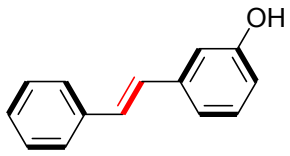
White solid (217 mg, 92% yield); R_f = 0.59 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.57 – 7.49 (m, 2H), 7.47 (d, *J* = 8.4 Hz, 2H), 7.40 (dd, *J* = 9.6, 2.4 Hz, 2H), 7.35 (t, *J* = 7.8 Hz, 2H), 7.26 – 7.23 (m, 1H), 7.17 – 7.00 (m, 2H), 1.35 (d, *J* = 3.0 Hz, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 150.7, 137.5, 134.5, 128.6 (2C), 128.5 (2C), 127.9 (2C), 127.4, 126.4, 126.2, 125.6 (2C), 34.6, 31.3, 31.3(2C); GC-MS (EI, 70 eV) m/z: 236, 221, 193, 178; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{18}H_{21}$, 237.1638, found: 237.1637.

(E)-trimethyl(4-styrylphenyl) silane (**Scheme 4, 20**) [8]



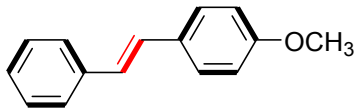
White solid (219 mg, 87% yield); R_f = 0.71 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.70 (d, *J* = 7.8 Hz, 2H), 7.67 (d, *J* = 7.8 Hz, 4H), 7.50 (t, *J* = 7.8 Hz, 2H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.32 (d, *J* = 16.8 Hz, 1H), 7.27 (d, *J* = 16.8 Hz, 1H), 0.49 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 139.8, 137.7, 137.3, 133.6 (2C), 128.9 (2C), 128.6 (2C), 128.6, 127.6 (2C), 126.5, 125.8, 1.1 (3C); GC-MS (EI, 70 eV) m/z: 252, 237, 207, 191.

(E)-3-styrylphenol (**Scheme4, 21**) [4]



white solid (186 mg, 95% yield); R_f = 0.47 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.6 Hz, 2H), 7.33 (t, *J* = 7.4 Hz, 2H), 7.31 – 7.11 (m, 3H), 7.05 (dd, *J* = 12.8, 8.0 Hz, 3H), 6.99 (s, 1H), 6.74 (d, *J* = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 139.0, 137.1, 129.8, 129.1 (2C), 128.6 (2C), 128.2, 127.7, 126.5, 119.3, 114.7, 113.0 ; GC-MS (EI, 70 eV) m/z: 196, 177, 165, 152 .

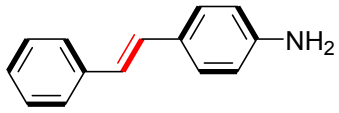
(E)-1-methoxy-4-styrylbenzene (**Scheme 4, 22**) [7]



White solid (189 mg, 90% yield); R_f = 0.67 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (t, *J* = 5.0 Hz, 2H), 7.46 – 7.42 (m, 2H), 7.33 (t, *J* = 7.8 Hz, 2H), 7.24 – 7.20 (m, 1H), 7.06 (d, *J* = 16.4 Hz, 1H), 6.96 (d, *J* = 16.4 Hz, 1H), 6.91 – 6.87 (m, 2H), 3.81 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.3, 137.6, 130.1 (2C), 128.6,

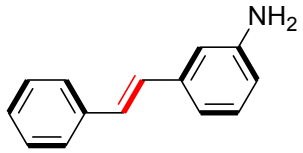
128.2 (2C), 127.7 (2C), 127.2, 126.6, 126.2, 114.1 (2C), 55.3 ; GC-MS (EI, 70 eV) m/z: 210, 195, 179, 139 .

(E)-4-styrylaniline (**Scheme 4, 23**) [7]



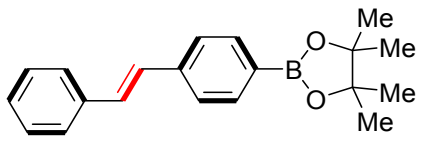
Gray solid (168 mg, 860% yield); R_f = 0.62 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.6 Hz, 2H), 7.35 (s, 2H), 7.34 – 7.26 (m, 2H), 7.22 (t, *J* = 7.4 Hz, 1H), 7.03 (d, *J* = 16.4 Hz, 1H), 6.93 (d, *J* = 16.4 Hz, 1H), 6.68 (d, *J* = 8.4 Hz, 2H), 3.74 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.1, 137.9, 128.7 (2C), 128.6 (2C), 128.0 (2C), 127.7, 126.9, 126.1, 125.1, 115.2 (2C); GC-MS (EI, 70 eV) m/z: 195, 180, 165, 139.

(E)-3-styrylaniline (**Scheme 4, 24**) [7]



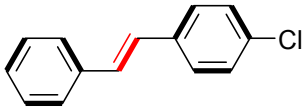
Gray solid (181 mg, 93% yield); R_f = 0.42 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.58 – 7.39 (m, 2H), 7.35 (dd, *J* = 7.2, 1.6 Hz, 2H), 7.26 – 7.18 (m, 1H), 7.13 (dd, *J* = 15.6, 7.6 Hz, 1H), 7.12 – 6.94 (m, 2H), 6.95 (t, *J* = 14.4 Hz, 1H), 6.91 – 6.71 (m, 1H), 6.70 – 6.33 (m, 1H), 3.65 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.6, 138.4, 137.4, 129.6 (2C), 128.9 (2C), 128.6, 128.5, 127.5, 126.5, 117.3, 114.7, 112.9; GC-MS (EI, 70 eV) m/z: 195, 178, 165, 152 .

(E)-4,4,5,5-tetramethyl-2-(4-styrylphenyl)-1,3,2-dioxaborolane (**Scheme 4, 25**) [8]



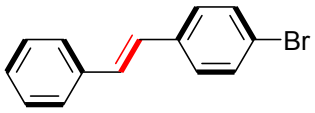
White solid (290 mg, 95% yield); R_f = 0.32 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.0 Hz, 2H), 7.54 – 7.45 (m, 4H), 7.32 (t, *J* = 7.6 Hz, 2H), 7.23 (t, *J* = 7.4 Hz, 1H), 7.17 – 7.12 (m, 1H), 7.08 (d, *J* = 16.4 Hz, 1H), 1.33 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.0, 137.1, 135.1 (2C), 129.6, 128.6 (2C), 128.6 (2C), 127.7, 126.6 (2C), 125.8 (2C), 83.7 (2C), 24.8 (4C); GC-MS (EI, 70 eV) m/z: 306, 291, 233, 220.

(E)-1-chloro-4-styrylbenzene (**Scheme 4, 26**) [7]



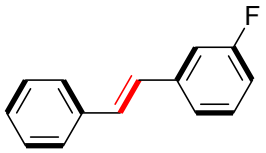
white solid (184 mg, 86% yield); R_f = 0.58 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.52 (d, *J* = 7.8 Hz, 2H), 7.45 (d, *J* = 8.4 Hz, 2H), 7.41 – 7.35 (m, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 7.29 (t, *J* = 7.5 Hz, 1H), 7.09 (d, *J* = 16.2 Hz, 1H), 7.06 (d, *J* = 16.2 Hz, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 137.0, 135.8, 133.1, 129.3 (2C), 128.8 (2C), 128.7 (2C), 127.8 (2C), 127.6, 127.3, 126.5 ; GC-MS (EI, 70 eV) m/z: 214, 178, 152, 115 .

(E)-1-bromo-4-styrylbenzene (**Scheme 4, 27**) [10]



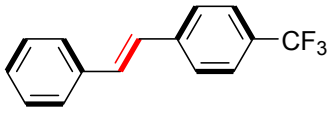
White solid (178 mg, 69% yield); R_f = 0.63 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.59 – 7.42 (m, 4H), 7.37 (d, *J* = 7.2 Hz, 4H), 7.27 (d, *J* = 11.4 Hz, 1H), 7.10 (d, *J* = 16.8 Hz, 1H), 7.03 (d, *J* = 16.2 Hz, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 136.9, 136.3, 131.8(2C), 129.4 (2C), 128.7 (2C), 128.0 (2C), 127.9, 127.4, 126.5, 121.3 ; GC-MS (EI, 70 eV) m/z: 258, 245, 178, 163.

(E)-1-fluoro-3-styrylbenzene (**Scheme 4, 28**) [11]



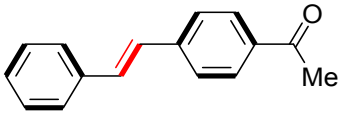
White solid (190 mg, 96% yield); R_f = 0.54 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (dd, *J* = 3.2, 1.6 Hz, 2H), 7.36 (dd, *J* = 8.4, 7.2 Hz, 2H), 7.30 (dd, *J* = 8.0, 2.0 Hz, 1H), 7.28 – 7.23 (m, 2H), 7.23 – 7.17 (m, 1H), 7.10 (d, *J* = 16.0 Hz, 1H), 7.04 (d, *J* = 16.4 Hz, 1H), 6.97 – 6.90 (m, 1H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.2 (d, *J* = 243.7 Hz, 1C), 139.8 (d, *J* = 7.7 Hz, 1C), 136.8, 130.07 (d, *J* = 8.3 Hz, 1C), 130.04, 128.7 (2C), 128.0, 127.5 (d, *J* = 2.6 Hz, 1C), 126.6 (2C), 122.4 (d, *J* = 3.0 Hz, 1C), 114.4 (d, *J* = 21.4 Hz, 1C), 112.8 (d, *J* = 16.7 Hz, 1C) ; GC-MS (EI, 70 eV) m/z: 198, 183, 177, 165 .

(E)-1-styryl-4-(trifluoromethyl) benzene (**Scheme 4, 29**) [7]



White solid (226 mg, 91% yield); R_f = 0.68 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.56 (q, *J* = 8.6 Hz, 4H), 7.50 (d, *J* = 7.5 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.28 (t, *J* = 7.3 Hz, 1H), 7.16 (d, *J* = 16.3 Hz, 1H), 7.08 (d, *J* = 16.3 Hz, 1H) ; ^{13}C NMR (150 MHz, DMSO) δ 148.9, 141.3, 136.9, 132.23, 129.2, 127.3 (q, $J_{C\text{-}F}$ = 31.5 Hz, 1C), 126.8 (2C), 125.8, 125.5 (q, $J_{C\text{-}F}$ = 3.75 Hz, 1C), 125.3, 123.5, 114.9, 114.4, 112.1; GC-MS (EI, 70 eV) m/z: 248, 233, 207, 179 .

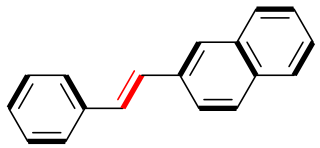
(E)-1-(4-styrylphenyl) ethan-1-one (**Scheme 4, 30**) [7]



White solid (200 mg, 89% yield); R_f = 0.47 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.0 Hz, 2H), 7.58 (d, *J* = 8.0 Hz, 2H), 7.54 (d, *J* = 7.6 Hz, 2H), 7.39 (t, *J* = 7.4 Hz, 2H), 7.31 (t, *J* = 7.4 Hz, 1H), 7.23 (d, *J* = 16.4 Hz,

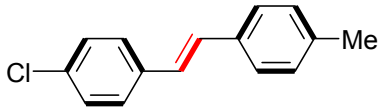
1H), 7.13 (d, J = 16.4 Hz, 1H), 2.60 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.4, 141.9, 136.6, 135.9, 131.4 (2C), 128.8 (2C), 128.7 (2C), 128.3 (2C), 127.4, 126.8, 126.4, 26.5; GC-MS (EI, 70 eV) m/z: 222, 207, 178, 152 .

(E)-2-styrylnaphthalene (**Scheme 4, 31**) [12]



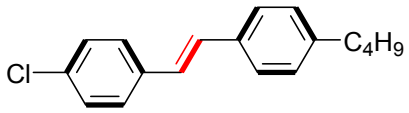
White solid (219 mg, 95% yield); R_f = 0.59 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.78 (d, J = 13.2 Hz, 2H), 7.76 (d, J = 8.4 Hz, 2H), 7.68 (d, J = 7.8 Hz, 1H), 7.51 (d, J = 6.6 Hz, 2H), 7.45 – 7.37 (m, 2H), 7.34 (s, 2H), 7.20 (dd, J = 28.2, 17.4 Hz, 3H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 137.3, 134.7, 133.6, 133.0, 128.9 (2C), 128.7 (2C), 128.7, 128.3, 128.0, 127.7, 127.6, 126.6, 126.5, 126.3, 125.8, 123.4; GC-MS (EI, 70 eV) m/z: 230, 215, 202, 189 .

(E)-1-chloro-4-(4-methylstyryl) benzene (**Scheme 4, 32**)



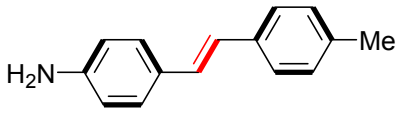
White solid (210 mg, 92% yield); R_f = 0.54 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.42 (t, J = 5.6 Hz, 2H), 7.41 – 7.36 (m, 2H), 7.33 – 7.26 (m, 2H), 7.18 (t, J = 10.0 Hz, 2H), 7.06 (d, J = 16.3 Hz, 1H), 7.00 (d, J = 16.3 Hz, 1H), 2.37 (d, J = 4.5 Hz, 3H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 137.8, 136.0, 134.2, 132.9, 129.4 (2C), 129.2 (2C), 128.8 (2C), 127.5 (2C), 126.4, 126.3, 21.3 ; GC-MS (EI, 70 eV) m/z: 228, 213, 192, 178.

(E)-1-butyl-4-(4-chlorostyryl) benzene (**Scheme 4, 33**)



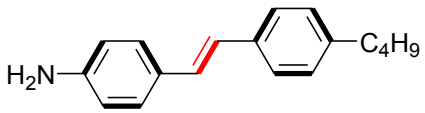
White solid (232 mg, 86% yield); mp 137-138 ℃; R_f = 0. 68 (petroleum ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 8.0 Hz, 4H), 7.34 – 7.20 (m, 2H), 7.15 (t, *J* = 12.2 Hz, 2H), 7.02 (d, *J* = 16.4 Hz, 1H), 6.96 (d, *J* = 16.0 Hz, 1H), 2.59 (t, *J* = 7.8 Hz, 2H), 1.66 – 1.54 (m, 2H), 1.39 – 1.29 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.9, 136.0, 134.4, 132.9, 129.3 (2C), 128.8 (2C), 128.8 (2C), 127.5 (2C), 126.5, 126.5, 35.4, 33.5, 22.3, 14.0; GC-MS (EI, 70 eV) m/z: 270, 227, 191, 178;

(E)-4-(4-methylstyryl) aniline (**Scheme 4, 34**) [14]



Gray solid (205 mg, 98% yield); R_f = 0.32 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (d, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.15 (d, *J* = 7.6 Hz, 2H), 6.95 (q, *J* = 16.4 Hz, 2H), 6.68 (d, *J* = 8.0 Hz, 2H), 3.73 (s, 2H), 2.36 (s, 3H) ; ^{13}C NMR (100MHz, $CDCl_3$) δ 145.9, 136.6, 135.1, 129.3 (2C), 128.2 (2C), 127.6 (2C), 127.6, 126.0, 125.0, 115.2 (2C), 21.2; GC-MS (EI, 70 eV) m/z: 209, 193, 165, 152 .

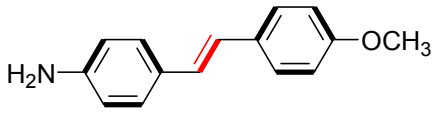
(E)-4-(4-butylstyryl)aniline (**Scheme 4, 35**)



Gray solid (161 mg, 64% yield); mp 105-107 ℃; R_f = 0.39 (ethyl acetate/petroleum ether = 1: 3); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.4 Hz, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 7.16 (d, *J* = 7.8 Hz, 2H), 7.00 (d, *J* = 16.2 Hz, 1H), 6.92 (d, *J* = 16.8 Hz, 1H), 6.68 (d, *J* = 7.8 Hz, 2H), 3.72 (s, 2H), 2.69 – 2.57 (m, 2H), 1.65-1.60 (m, 2H), 1.38 (dt, *J* = 22.8, 22.2 Hz, 2H), 0.95 (t, *J* = 7.5 Hz, 3H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 145.9, 141.8, 135.3, 128.6 (2C), 128.2 (2C), 127.7 (2C), 127.6, 126.0,

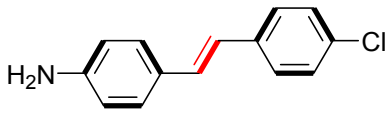
125.1, 115.2 (2C), 35.4, 33.6, 22.3, 13.9; GC-MS (EI, 70 eV) m/z: 251, 208, 193, 165 ; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{18}H_{221}N$, 252.1747, found: 252.1744.

(E)-4-(4-methoxystyryl)aniline (**Scheme 4, 36**) [15]



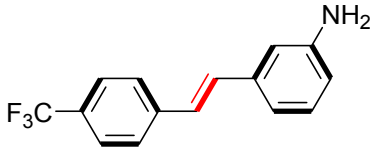
Gray solid (180 mg, 80% yield); R_f = 0.38 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.42 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 6.94 – 6.87 (m, 4H), 6.67 (d, *J* = 7.8 Hz, 2H), 3.82 (s, 3H), 3.71 (s, 2H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 158.7, 145.8, 130.7(2C), 128.3, 127.4 (2C), 127.2, 126.6, 124.7, 115.2 (2C), 114.0 (2C), 55.3; GC-MS (EI, 70 eV) m/z: 225, 210, 180, 152 .

(E)-4-(4-chlorostyryl)aniline (**Scheme 4, 37**) [14]



Gray solid (224 mg, 98% yield); R_f = 0.41 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 8.4 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.29 – 7.23 (m, 2H), 6.97 (d, *J* = 16.4 Hz, 1H), 6.84 (d, *J* = 16.4 Hz, 1H), 6.65 (d, *J* = 8.4 Hz, 2H), 3.74 (s, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.3, 136.5, 132.3, 129.3 (2C), 128.7 (2C), 127.8 (2C), 127.6, 127.2, 123.7, 115.2 (2C); GC-MS (EI, 70 eV) m/z: 229, 214, 193, 177 .

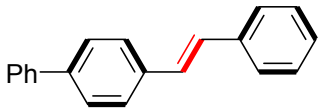
(E)-3-(4-(trifluoromethyl) styryl) aniline (**Scheme 4, 38**)



Yellow solid (210 mg, 80% yield); R_f = 0.35 (ethyl acetate/petroleum ether = 1: 3); ^{1}H NMR (600 MHz, DMSO) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.68 (d, *J* = 7.8 Hz, 2H), 7.26 (d, *J* = 16.2 Hz, 1H), 7.15 (d, *J* = 16.2 Hz, 1H), 7.05 (t, *J* = 7.8 Hz, 1H), 6.86 – 6.71 (m,

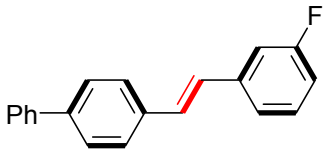
2H), 6.56 (dd, J = 7.8, 1.2 Hz, 1H), 5.15 (s, 2H) ; ^{13}C NMR (150 MHz, DMSO) δ = 148.9, 141.3, 136.9, 132.3, 129.2, 127.34 (q, $J_{C\text{-}F}$ =31.5 Hz, 1C), 126.8, 125.8 (2C), 125.5 (q, $J_{C\text{-}F}$ = 3.75 Hz, 1C), 125.3, 123.5, 114.9, 114.4, 112.1; GC-MS (EI, 70 eV) m/z: 263, 242, 227, 193 ; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{15}H_{13}F_3N$, 264.0995, found: 264.0991.

(E)-4-styryl-1,1'-biphenyl (**Scheme 4, 39**) [7]



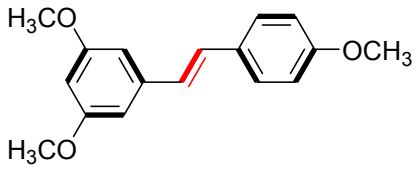
White solid (246 mg, 96% yield); R_f = 0.42 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.64 – 7.58 (m, 5H), 7.56 – 7.51 (m, 2H), 7.47 – 7.43 (m, 2H), 7.39 – 7.33 (m, 3H), 7.30 – 7.24 (m, 2H), 7.16 (s, 2H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 140.6, 140.3, 137.3, 136.3, 128.8 (2C), 128.7(2C), 128.7 (2C), 128.2 (2C), 127.6 (3C), 127.3, 127.3, 126.9, 126.9, 126.5; GC-MS (EI, 70 eV) m/z: 256, 239, 207, 178.

(E)-4-(3-fluorostyryl)-1,1'-biphenyl (**Scheme 4, 40**)



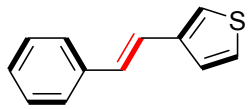
White solid (260 mg, 95% yield); mp 170-172 ℃; R_f = 0.69 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.61 (dd, J = 6.6, 6.0 Hz, 4H), 7.57 (d, J = 8.4 Hz, 2H), 7.44 (t, J = 7.8 Hz, 2H), 7.35 (t, J = 7.2 Hz, 1H), 7.32 – 7.28 (m, 1H), 7.27 (d, J = 7.8 Hz, 1H), 7.24-7.22 (m, 1H), 7.13 (d, J = 16.8 Hz, 1H), 7.09 (d, J = 16.2 Hz, 1H), 6.98 – 6.93 (m, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 163.1 (d, J = 243.75 Hz, 1C), 140.5 (d, J = 25.2 Hz, 1C), 139.6 (d, J = 7.65 Hz, 1C), 135.8, 130.1 (d, J = 8.4 Hz, 1C), 129.4, 128.8 (2C), 128.7, 127.4 (d, J =2.55 Hz, 1C), 127.37, 127.3 (2C), 127.0 (2C), 126.9 (2C), 122.4 (d, J = 2.55 Hz, 1C), 114.3 (d, J = 21.3 Hz, 1C), 112.7 (d, J = 22.5 Hz, 1C); GC-MS (EI, 70 eV) m/z: 274, 252, 220, 196 .

(E)-1,3-dimethoxy-5-(4-methoxystyryl)benzene (**Scheme 4, 41**) [8]



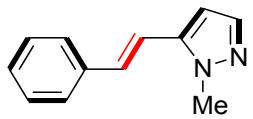
Red liquid (54 mg, 20% yield); R_f = 0.39 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (d, *J* = 8.4 Hz, 2H), 7.06 (d, *J* = 16.4 Hz, 1H), 6.95 – 6.88 (m, 3H), 6.68 (s, 2H), 6.40 (s, 1H), 3.84 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.9 (2C), 159.3, 139.6, 129.9 (2C), 128.7, 127.7 (2C), 126.5, 114.1 (2C), 104.3 (2C), 99.6, 55.2 (2C); GC-MS (EI, 70 eV) m/z: 270, 255, 239, 224.

(E)-3-styrylthiophene (**Scheme 4, 42**) [7]



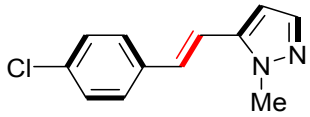
White solid (171 mg, 92% yield); R_f = 0.57 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.44 (d, *J* = 7.2 Hz, 2H), 7.36 – 7.29 (m, 3H), 7.29 – 7.24 (m, 1H), 7.24 – 7.15 (m, 2H), 7.09 (d, *J* = 16.2 Hz, 1H), 6.92 (d, *J* = 16.2 Hz, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 140.0, 137.3, 128.6(2C), 128.6(2C), 127.4, 126.2, 126.1, 124.9, 122.8, 122.3; GC-MS (EI, 70 eV) m/z: 186, 171, 152, 141.

(E)-1-methyl-5-styryl-1H-pyrazole (**Scheme 4, 43**) [16]



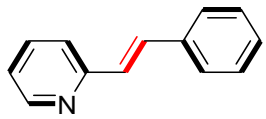
White solid (151 mg, 82% yield); R_f = 0.46 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.42 (m, 3H), 7.36 (dd, *J* =6.8, 5.6 Hz, 2H), 7.28 (dd, *J* = 7.6, 6.0 Hz, 1H), 7.01 (dd, *J* = 16.0, 1.6 Hz, 1H), 6.91 (dd, *J* = 16.0, 1.6 Hz, 1H), 6.46 (s, 1H), 3.91 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.7, 138.4, 136.4, 131.9, 128.7 (2C), 128.2 (2C), 126.4, 114.4, 102.8, 36.5; GC-MS (EI, 70 eV) m/z: 184, 168, 156, 128 .

(E)-5-(4-chlorostyryl)-1-methyl-1H-pyrazole (**Scheme 4, 44**)



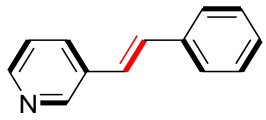
White solid (166 mg, 76% yield); R_f = 0.39 (ethyl acetate/petroleum ether = 1: 3); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.44 (d, *J* = 1.8 Hz, 1H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 6.97 (d, *J* = 16.2 Hz, 1H), 6.90 (d, *J* = 16.2 Hz, 1H), 6.48 (d, *J* = 1.8 Hz, 1H), 3.94 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 140.5, 138.5, 135.0, 133.9, 130.6, 129.0 (2C), 127.7 (2C), 115.0, 103.0, 36.6; GC-MS (EI, 70 eV) m/z: 218, 202, 190, 168; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{12}H_{12}ClN_2$, 219.0684, found:219.0681.

(E)-2-styrylpyridine (**Scheme 5, 45**) [17]



White solid (165 mg, 91% yield); R_f = 0.44 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.59 (d, *J* = 4.8 Hz, 1H), 7.63 (d, *J* = 16.0 Hz, 2H), 7.57 (d, *J* = 8.0 Hz, 2H), 7.36 (t, *J* = 7.2 Hz, 3H), 7.27 (dd, *J* = 14.4, 7.6 Hz, 1H), 7.16 (d, *J* = 16.4 Hz, 1H), 7.13 – 7.07 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 149.5, 136.5, 136.5, 132.7, 128.6 (2C), 128.3 (2C), 127.8, 127.0, 122.0, 122.0 ; GC-MS (EI, 70 eV) m/z: 181, 166, 152, 127 .

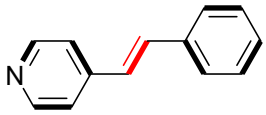
(E)-3-styrylpyridine (**Scheme 5, 46**) [18]



White solid (157 mg, 87% yield); R_f = 0.46 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.72 (s, 1H), 8.48 (s, 1H), 7.80 (d, *J* = 7.8 Hz, 1H), 7.51 (d, *J* = 7.8 Hz, 2H), 7.36 (t, *J* = 7.5 Hz, 2H), 7.31 – 7.18 (m, 2H), 7.14 (d, *J* = 16.8 Hz,

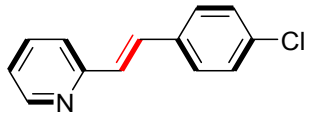
1H), 7.05 (d, *J* = 16.8 Hz, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 148.5 (2C), 136.5, 132.5 (2C), 130.7, 128.7(2C), 128.1 (2C), 126.6, 124.8, 123.5; GC-MS (EI, 70 eV) m/z: 181, 166, 152, 139.

(E)-4-styrylpyridine (**Scheme 5, 47**) [19]



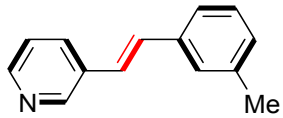
White solid (118 mg, 65% yield); R_f = 0.41 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.58 (d, *J* = 5.2 Hz, 2H), 7.54 (d, *J* = 7.6 Hz, 2H), 7.40 (d, *J* = 7.2 Hz, 2H), 7.37 – 7.34 (m, 2H), 7.32 (s, 1H), 7.28 (t, *J* = 9.4 Hz, 1H), 7.01 (d, *J* = 16.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.0 (2C), 144.7, 136.1, 133.2, 128.8 (2C), 128.7 (2C), 127.0, 125.9, 120.8 (2C); GC-MS (EI, 70 eV) m/z: 181, 166, 152, 115 .

(E)-2-(4-chlorostyryl)pyridine (**Scheme 5, 48**) [17]



White solid (200 mg, 93% yield); R_f = 0.38 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (s, 1H), 7.66 – 7.56 (m, 2H), 7.48 (d, *J* = 7.8 Hz, 2H), 7.36 – 7.28 (m, 3H), 7.12 (d, *J* = 17.4 Hz, 2H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 155.1, 149.6, 136.6, 135.1, 133.9, 131.3, 128.8 (2C), 128.3 (2C), 128.2, 122.2, 122.2 ; GC-MS (EI, 70 eV) m/z: 215, 186, 178, 136 ;

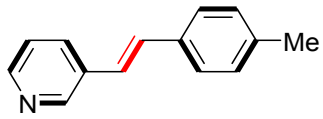
(E)-3-(3-methylstyryl)pyridine (**Scheme 5, 49**) [20]



White solid (177 mg, 92% yield); R_f = 0.41 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.46 (d, *J* = 4.0 Hz, 1H), 7.78 (dd, *J* = 8.0,

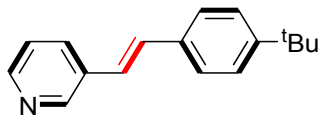
1.6 Hz, 1H), 7.30 (d, J = 9.6 Hz, 2H), 7.24 (dd, J = 9.2, 7.2 Hz, 2H), 7.14 – 7.06 (m, 2H), 7.02 (d, J = 16.4 Hz, 1H), 2.36 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.4, 148.4, 138.3, 136.5, 133.0, 132.5, 130.9, 129.0, 128.6, 127.3, 124.6, 123.8, 123.4, 21.3 ; GC-MS (EI, 70 eV) m/z: 195, 180, 152, 115 ;

(E)-3-(4-methylstyryl)pyridine (**Scheme 5, 50**) [21]



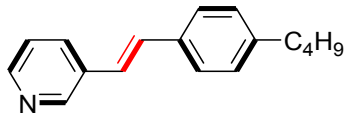
White solid (179 mg, 92% yield); R_f = 0.37 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.60 (d, J = 4.4 Hz, 1H), 7.67 – 7.55 (m, 2H), 7.48 (d, J = 8.0 Hz, 2H), 7.37 (d, J = 7.6 Hz, 1H), 7.18 (d, J = 8.0 Hz, 2H), 7.16 – 7.09 (m, 2H), 2.37 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 149.5, 138.3, 136.5, 133.8, 132.7, 129.4, 127.0 (2C), 126.9 (2C), 121.9, 121.8, 21.3; GC-MS (EI, 70 eV) m/z: 195, 180, 167, 152 ;

(E)-3-(4-(tert-butyl) styryl) pyridine (**Scheme 5, 51**)



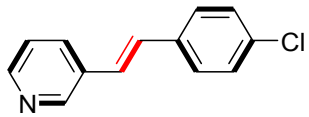
White solid (223 mg, 94% yield); mp 83-85 ℃; R_f = 0.49 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.72 (s, 1H), 8.48 (d, J = 4.2 Hz, 1H), 7.82 (d, J = 7.8 Hz, 1H), 7.47 (d, J = 8.4 Hz, 2H), 7.41 (d, J = 8.4 Hz, 2H), 7.29 – 7.26 (m, 1H), 7.15 (d, J = 16.2 Hz, 1H), 7.03 (d, J = 16.2 Hz, 1H), 1.34 (s, 9H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 151.5, 148.4, 148.2, 133.8, 133.2, 132.6, 130.7, 126.4 (2C), 125.7 (2C), 124.0, 123.5, 34.7, 31.2 (3C) ; GC-MS (EI, 70 eV) m/z: 237, 222, 206, 194 ; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{17}H_{20}N$, 238.1590, found: 238.1589.

(E)-3-(4-butylstyryl)pyridine (**Scheme 5, 52**)



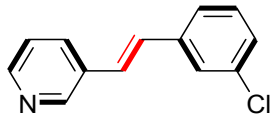
White solid (223 mg, 94% yield); R_f = 0.36 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.46 (d, *J* = 4.2 Hz, 1H), 7.79 (dt, *J* = 8.4, 8.4 Hz, 1H), 7.43 (d, *J* = 8.4 Hz, 2H), 7.25 (dd, *J* = 7.8, 4.2 Hz, 1H), 7.18 (d, *J* = 8.4 Hz, 2H), 7.13 (d, *J* = 16.2 Hz, 1H), 7.01 (d, *J* = 16.2 Hz, 1H), 2.71 – 2.55 (m, 2H), 1.63-1.58 (m, 2H), 1.39-1.33 (m, 2H), 0.93 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 148.3, 148.2, 143.2, 134.0, 133.1, 132.4, 130.7, 128.8 (2C), 126.5 (2C), 123.7, 123.4, 35.3, 33.4, 22.3, 13.9 ; GC-MS (EI, 70 eV) m/z: 237, 194, 180, 115 ;

(E)-3-(4-chlorostyryl) pyridine (**Scheme 5, 53**) [21]



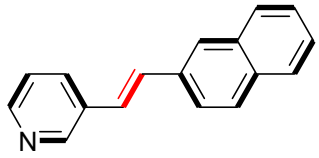
White solid (178 mg, 83% yield); R_f = 0.35 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.71 (s, 1H), 8.49 (s, 1H), 7.81 (s, 1H), 7.43 (s, 2H), 7.34 (s, 2H), 7.28 (s, 1H), 7.10 (d, *J* = 16.2 Hz, 1H), 7.03 (d, *J* = 16.8 Hz, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 148.7, 148.4, 135.1, 133.8, 132.7, 132.6, 129.4, 128.9 (2C), 127.8 (2C), 125.4, 123.5 ; GC-MS (EI, 70 eV) m/z: 215, 180, 152, 136 .

(E)-3-(3-chlorostyryl)pyridine (**Scheme 5, 54**)



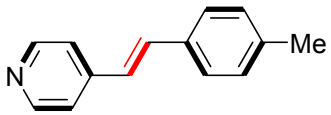
White liquid (2185 mg, 86% yield); R_f = 0.41 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.63 (d, *J* = 129.6 Hz, 2H), 7.83 (d, *J* = 8.4 Hz, 1H), 7.51 (t, *J* = 1.3 Hz, 1H), 7.38 (d, *J* = 7.2 Hz, 1H), 7.36 – 7.27 (m, 2H), 7.27-7.25(m, 1H), 7.15 – 7.02 (m, 2H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 148.7, 148.4, 138.4, 134.7, 132.9, 130.0(2C), 129.4, 128.1, 126.4, 126.2, 124.9, 123.7 ; GC-MS (EI, 70 eV) m/z: 215, 180, 152, 127 .

(E)-3-(2-(naphthalen-2-yl) vinyl) pyridine (**Scheme 5, 55**)



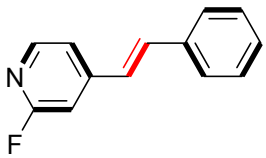
White solid (203 mg, 88% yield); R_f = 0.39 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.75 (d, *J* = 1.8 Hz, 1H), 8.51 – 8.44 (m, 1H), 7.83 (d, *J* = 3.0 Hz, 2H), 7.81 (t, *J* = 7.5 Hz, 3H), 7.70 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.48-7.44 (m, 2H), 7.30 – 7.24 (m, 2H), 7.15 (d, *J* = 16.8 Hz, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 148.4, 148.4, 134.0, 133.5, 133.2, 133.0, 132.6, 130.8, 128.4, 128.0, 127.6, 127.1, 126.4, 126.2, 125.0, 123.5, 123.2; GC-MS (EI, 70 eV) m/z: 231, 216, 202, 176 ; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{17}H_{14}N$, 232.1121, found: 232.1119.

(E)-4-(4-methylstyryl)pyridine (**Scheme 5, 56**) [13]



White solid (181 mg, 93% yield); R_f = 0.43 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.56 (d, *J* = 5.6 Hz, 2H), 7.43 (d, *J* = 8.4 Hz, 2H), 7.34 (d, *J* = 6.0 Hz, 2H), 7.29 – 7.24 (m, 1H), 7.19 (d, *J* = 8.0 Hz, 2H), 6.96 (d, *J* = 16.4 Hz, 1H), 2.37 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.1 (2C), 144.8, 138.8, 133.4, 133.1, 129.5 (2C), 126.9 (2C), 124.9, 120.7 (2C), 21.3 ; GC-MS (EI, 70 eV) m/z: 195, 180, 165, 128 .

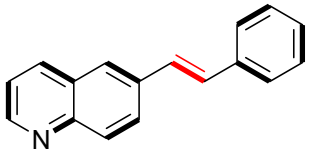
(E)-2-fluoro-4-styrylpyridine (**Scheme 5, 57**)



White liquid (177 mg, 89% yield); R_f = 0.42 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.18 (d, *J* = 4.8 Hz, 1H), 7.54 (d, *J* = 7.2 Hz, 2H), 7.40 (t,

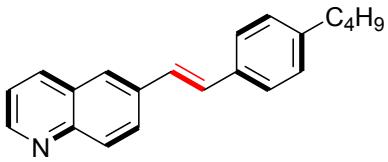
J = 7.5 Hz, 2H), 7.34 (dd, *J* = 15.0, 7.2 Hz, 2H), 7.29 (d, *J* = 7.8 Hz, 1H), 7.02 (d, *J* = 16.2 Hz, 1H), 6.98 (s, 1H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.6 (d, *J* = 235.95 Hz, 1C), 150.3 (d, *J* = 8.4 Hz, 1C), 147.85 (d, *J* = 15.6 Hz, 1C), 135.6, 134.5, 129.1, 128.9 (2C), 127.2 (2C), 124.8 (d, *J* = 3.75 Hz, 1C), 118.6 (d, *J* = 3.9 Hz, 1C), 106.3 (d, *J* = 37.8 Hz, 1C) ; GC-MS (EI, 70 eV) m/z: 199, 178, 170, 151 .

(E)-6-styrylquinoline (**Scheme 5, 58**) [9]



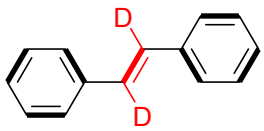
White solid (222 mg, 96% yield); R_f = 0.46 (ethyl acetate/petroleum ether = 1: 5); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.88 (d, *J* = 3.2 Hz, 1H), 8.11 (t, *J* = 7.0 Hz, 2H), 8.02 – 7.94 (m, 1H), 7.77 (d, *J* = 15.6 Hz, 1H), 7.66 – 7.51 (m, 2H), 7.49 – 7.39 (m, 2H), 7.39 – 7.29 (m, 2H), 7.26 (s, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.9, 147.9, 136.9, 135.8, 135.4, 130.1, 129.6 (2C), 128.7 (2C), 128.4, 127.9, 127.7, 127.1, 126.5, 125.8, 121.4 ; GC-MS (EI, 70 eV) m/z: 231, 216, 202, 176.

(E)-6-(4-butylstyryl)quinolone (**Scheme 5, 59**)



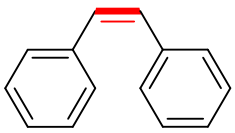
white solid (255 mg, 89% yield); R_f = 0.41 (ethyl acetate/petroleum ether = 1: 10); ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.94 – 8.69 (m, 1H), 8.35 – 7.95 (m, 2H), 7.92 (d, *J* = 8.4 Hz, 1H), 7.67 (dd, *J* = 51.0, 1.2Hz, 1H), 7.61 – 7.38 (m, 2H), 7.38 – 7.27 (m, 1H), 7.27 – 7.19 (m, 2H), 7.17 (d, *J* = 15.0 Hz, 2H),2.65-2.61 (m, 2H), 1.73 – 1.52 (m, 2H), 1.44 – 1.32 (m, 2H), 1.05 – 0.90 (m, 3H) ; ^{13}C NMR (150 MHz, $CDCl_3$) δ 149.8, 147.8, 142.9, 135.7, 135.6, 134.3, 130.0, 129.5, 129.0, 128.7, 128.4 (2C), 127.1, 126.7, 126.5, 125.5, 121.3, 35.3, 33.4, 22.2, 13.9; GC-MS (EI, 70 eV) m/z: 287, 244, 230, 216 ; ESI-HRMS (m/z): $[M+H]^+$ calcd for $C_{21}H_{22}N$, 288.1748, found: 288.1745.

(E)-1,2-diphenylethene-1,2-d2 (**Scheme , 2-D**) [7]



White solid (164 mg, 91% yield); R_f = 0.51 (petroleum ether); ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.49 (dd, *J* = 8.0, 1.3 Hz, 4H), 7.33 (t, *J* = 7.7 Hz, 4H), 7.24 (dd, *J* = 10.6, 4.1 Hz, 2H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 137.2 (2C), 128.6 (4C), 127.6 (4C), 126.4 (4C); GC-MS (EI, 70 eV) m/z: 182, 175, 167, 153.

(Z)-1,2-diphenylethene (**Scheme 5f**)



White liquid, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.25-7.16 (m, 10H), 6.59 (s, 2H).

References:

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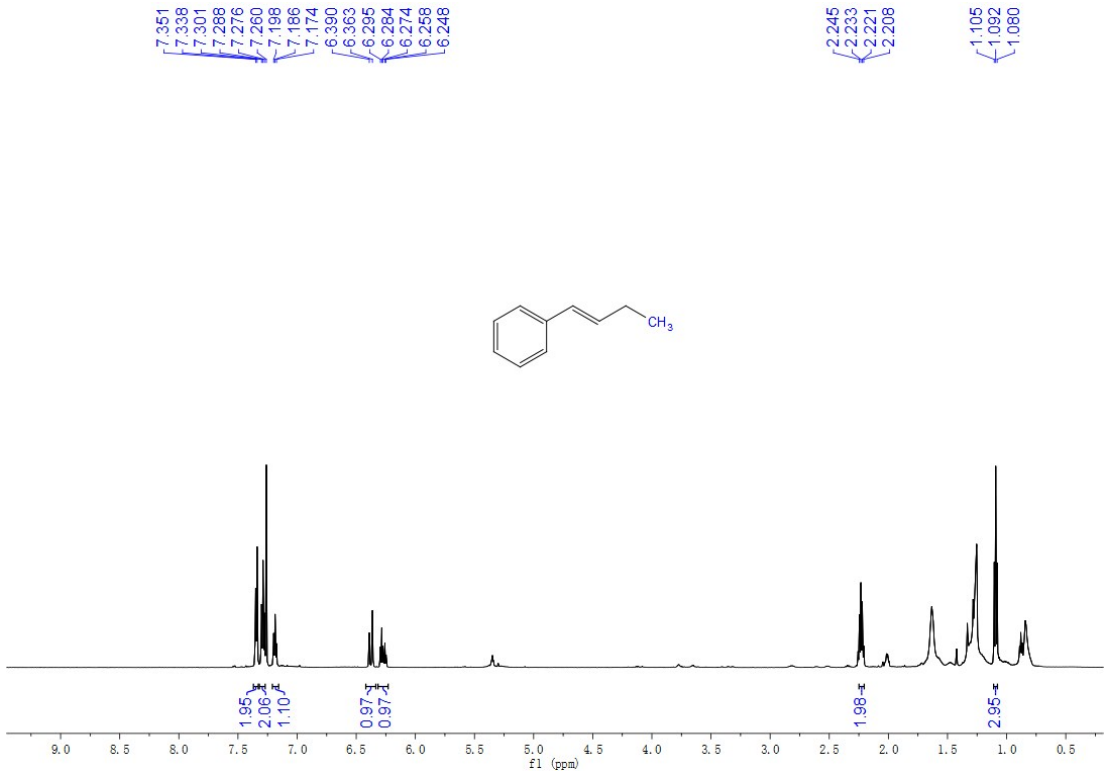
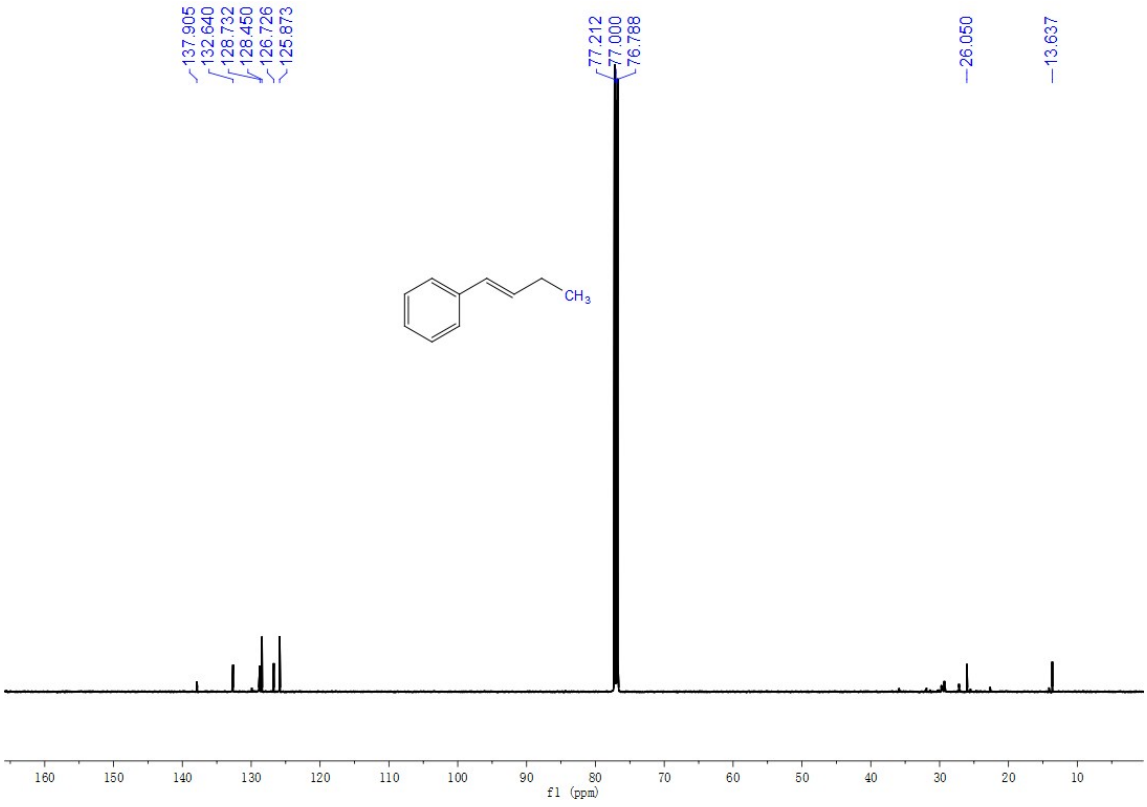
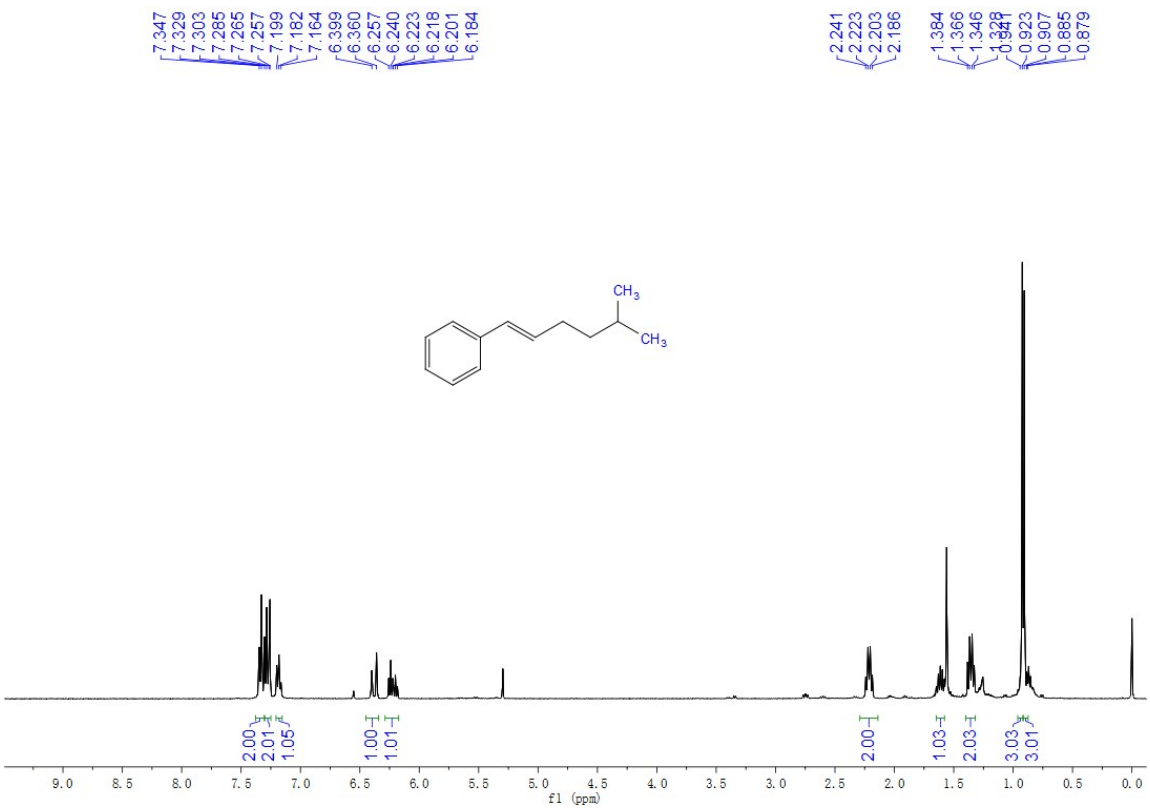
F ^{1}H NMR and ^{13}C NMR spectra for products



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7.182
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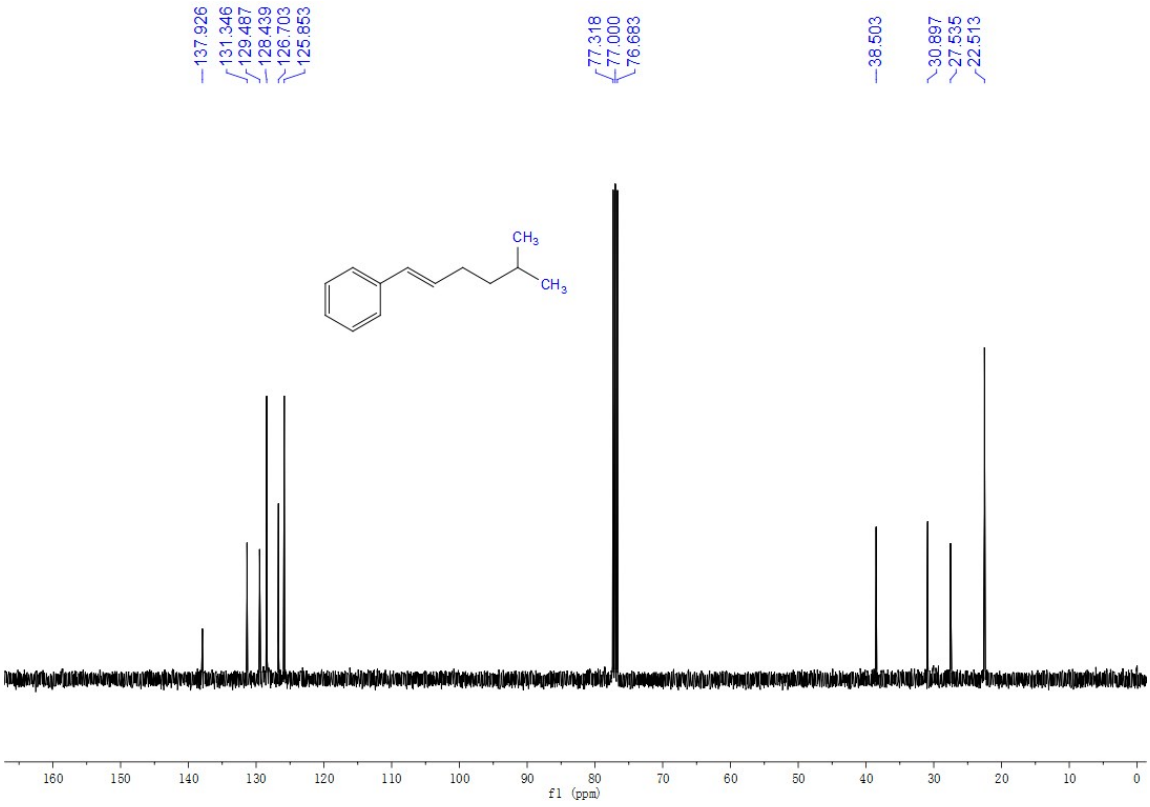
6.223
6.218
6.201
6.184
2.241
2.223
2.203
2.186
1.384
1.366
1.346
0.923
0.907
0.885
0.879
CH3
CH3
2.00
2.01
1.05
1.00
1.01
2.00
1.03
2.03
3.03
3.01
f1 (ppm)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131.346
129.487
128.439
126.703
125.853
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77.000
76.683
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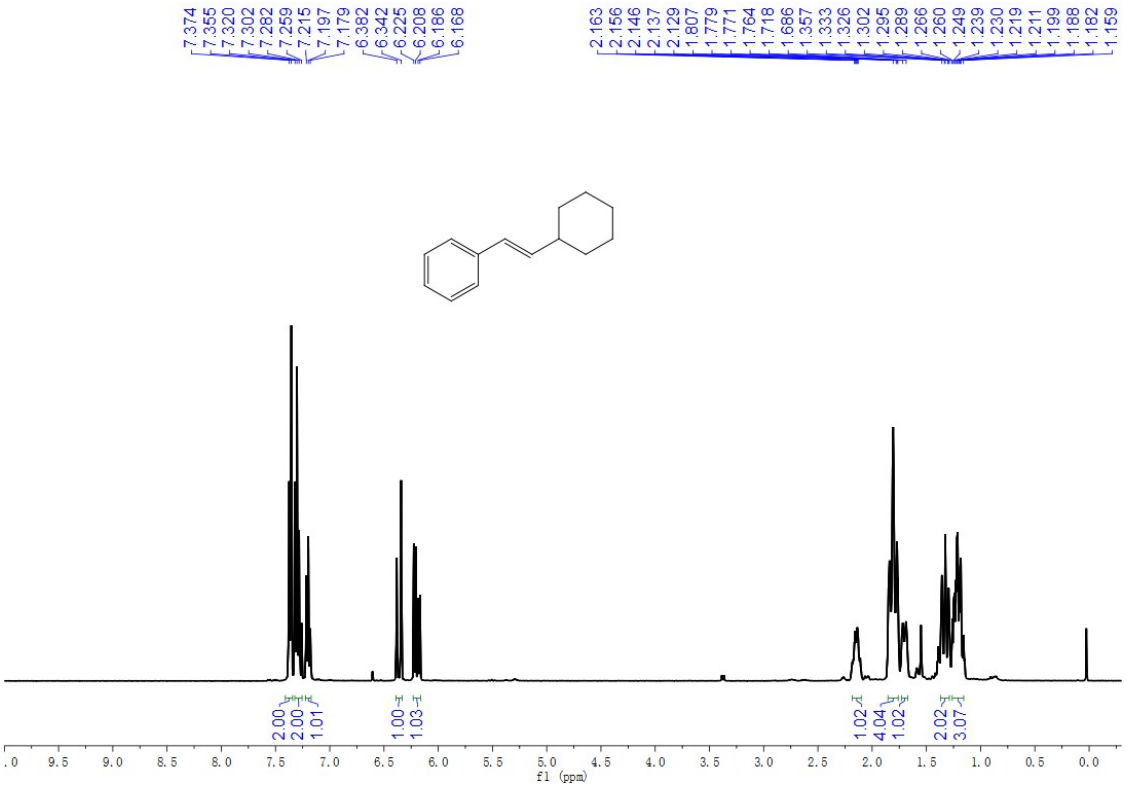
27.535
22.513
CH3
CH3
f1 (ppm)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7.259
7.215
7.197
7.179
6.382
6.342
6.225
6.208
6.186
6.168
2.163
2.156
2.146
2.137
2.129
1.807
1.779
1.771
1.764
1.718
1.686
1.357
1.333
1.326
1.302
1.295
1.289
1.266
1.260
1.249
1.239
1.230
1.219
1.211
1.199
1.188
1.182
1.159
2.00
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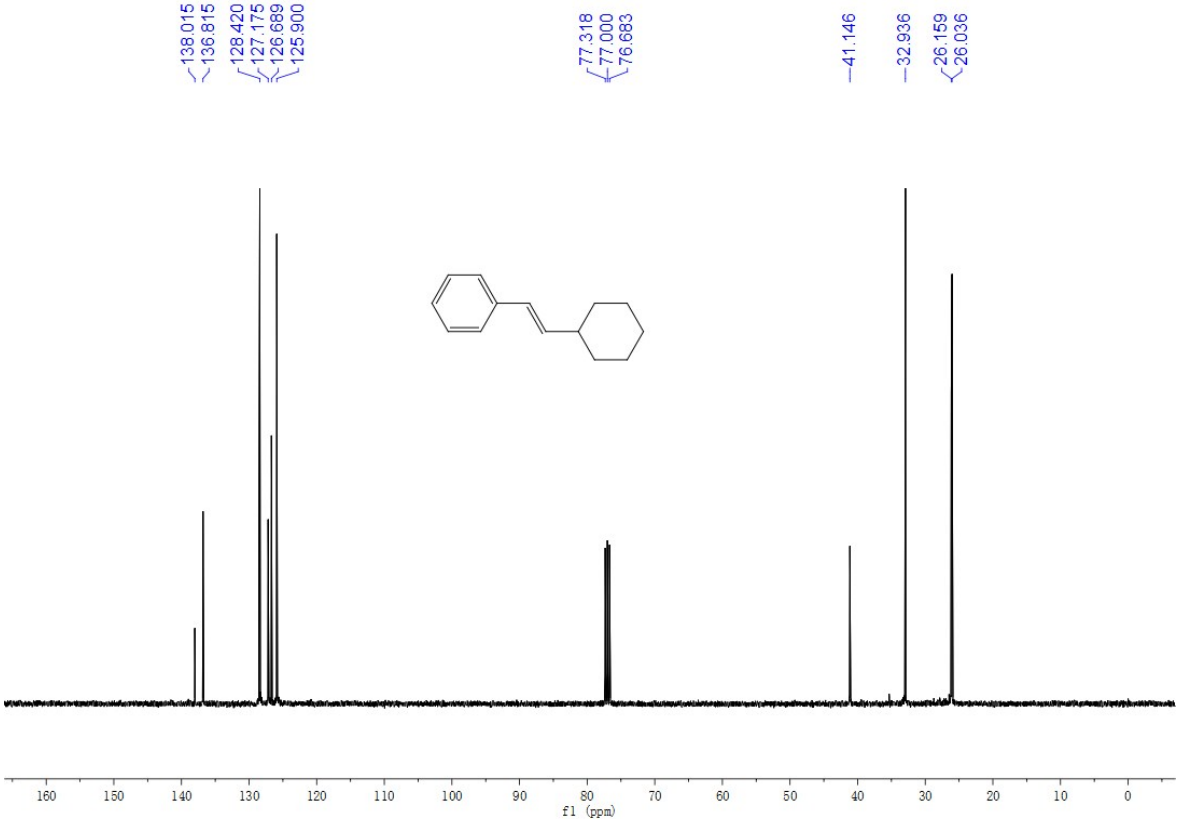
1.01
1.00
1.03
1.02
4.04
1.02
2.02
3.07
f1 (ppm)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32.936
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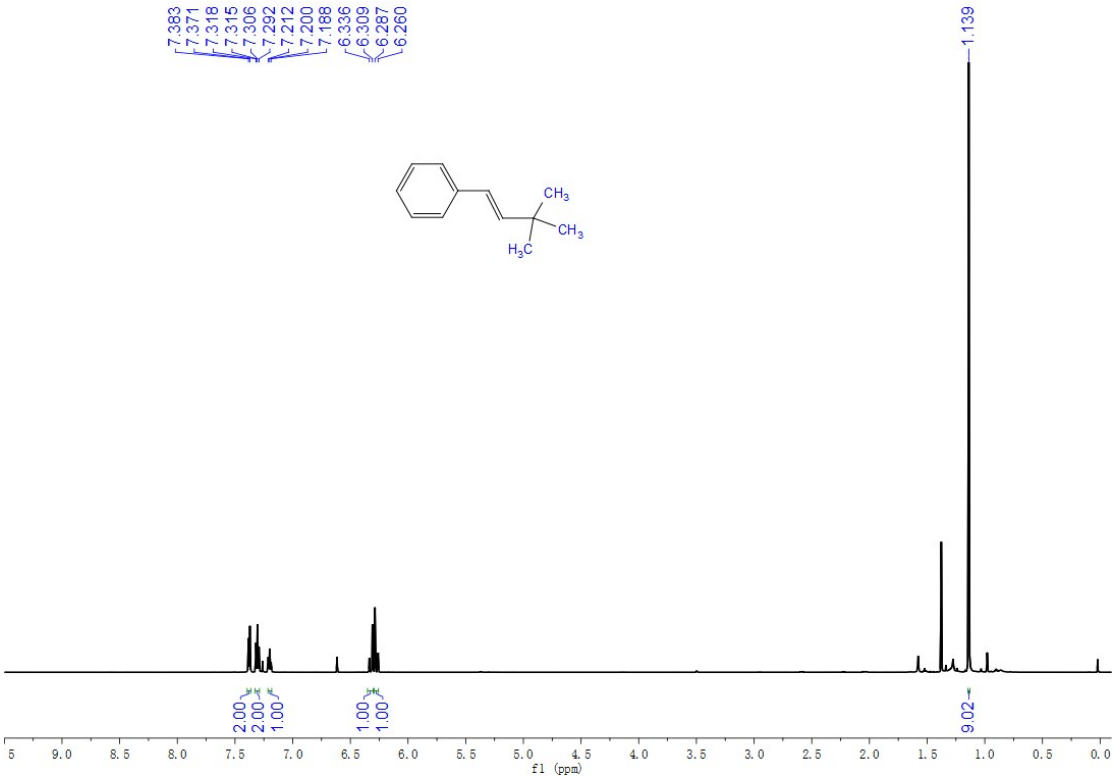
26.036
f1 (ppm)


7.383
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7.212
7.200
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6.336
6.309
6.287
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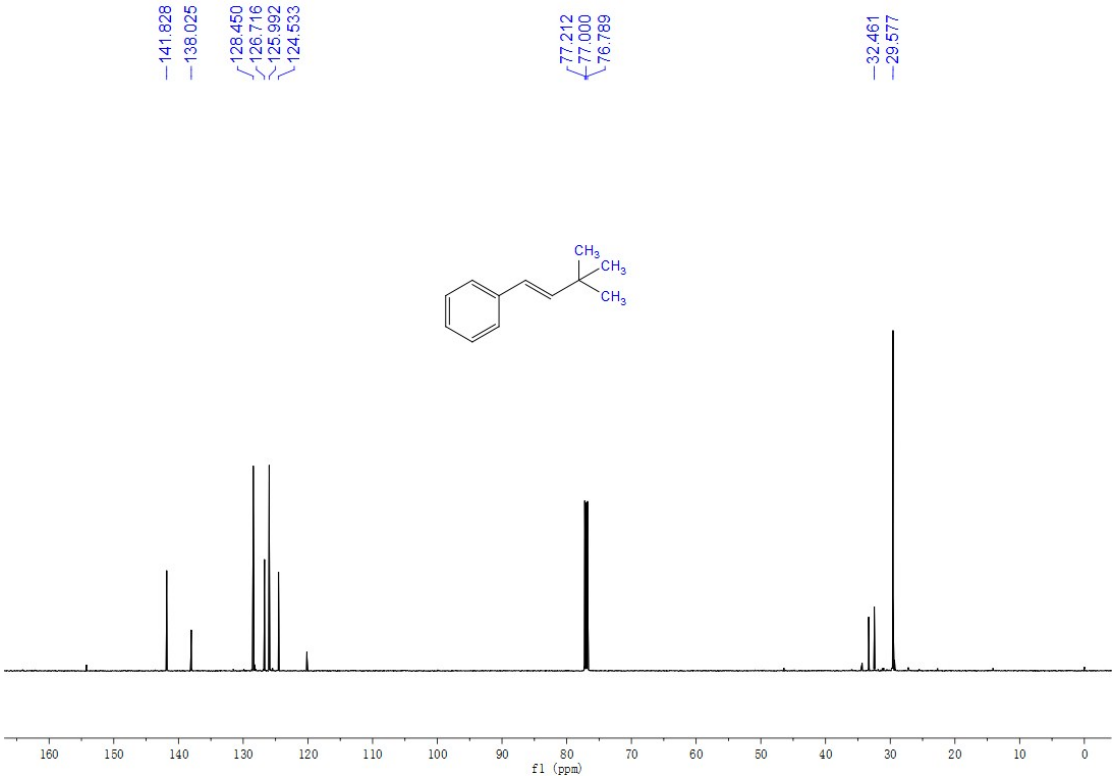
H3C
2.00
2.00
1.00
1.00
1.00
9.02
f1 (ppm)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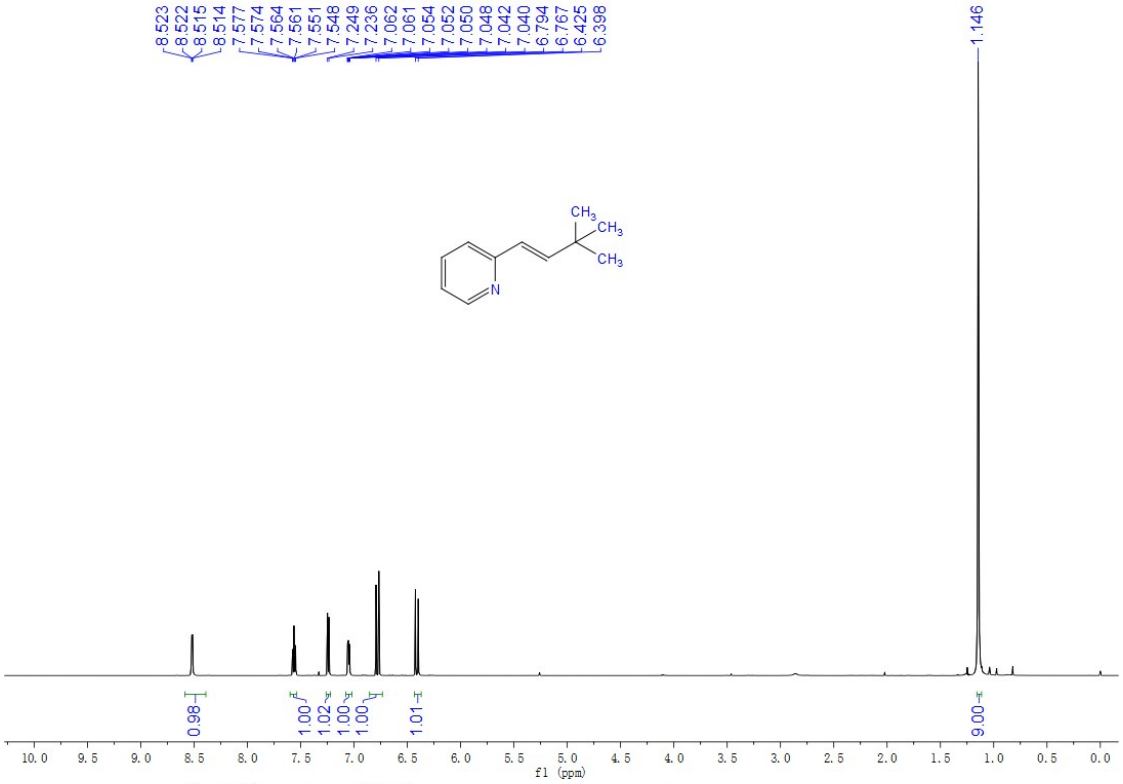
CH3
f1 (ppm)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7.561
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7.548
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7.236
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7.054
7.052
7.050
7.048
7.042
7.040
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6.767
6.425
6.398
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CH3
N
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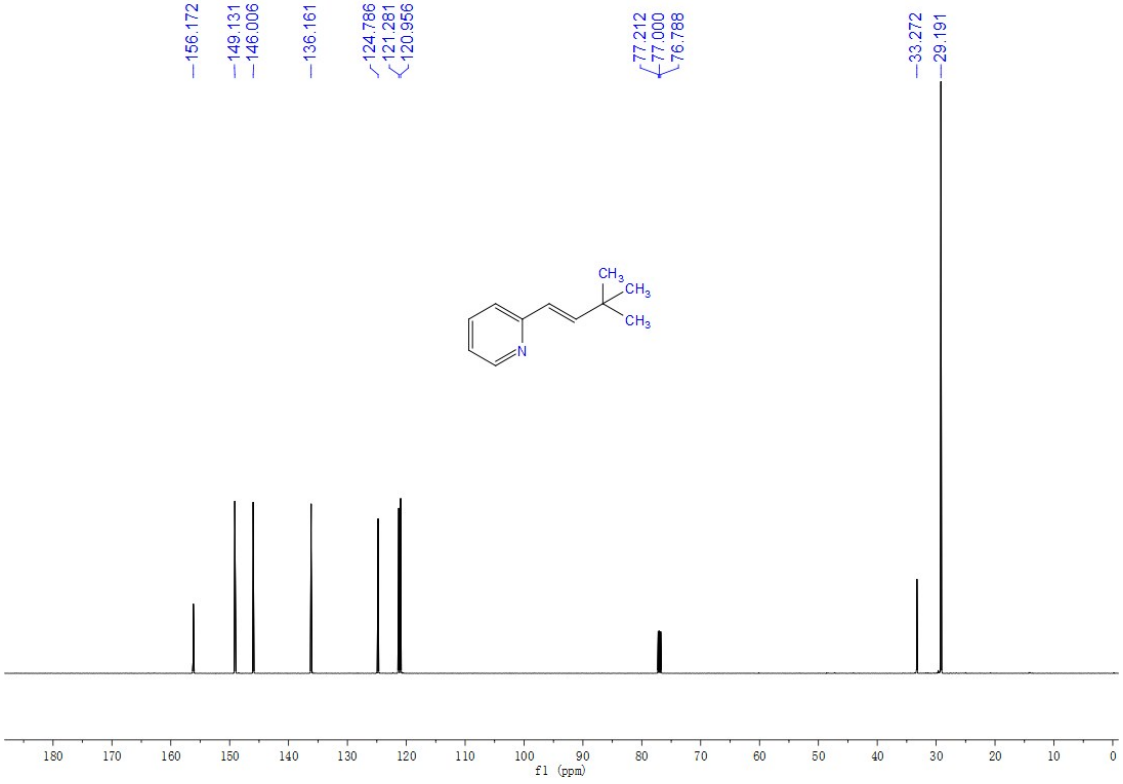
1.00
1.02
1.00
1.00
1.01
9.00
f1 (ppm)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149.131
146.006
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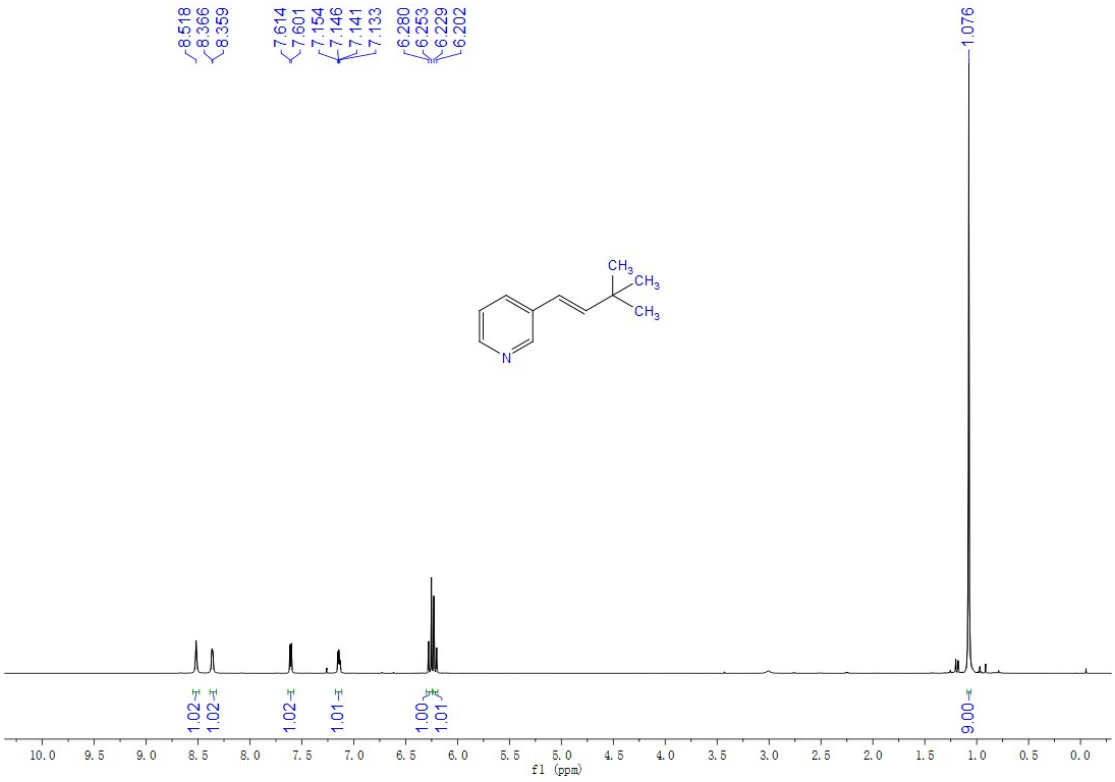
77.000
76.788
33.272
29.191
CH3
CH3
CH3
N
f1 (ppm)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8.366
8.359
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7.154
7.146
7.141
7.133
6.280
6.253
6.229
6.202
1.076
CH3
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CH3
N
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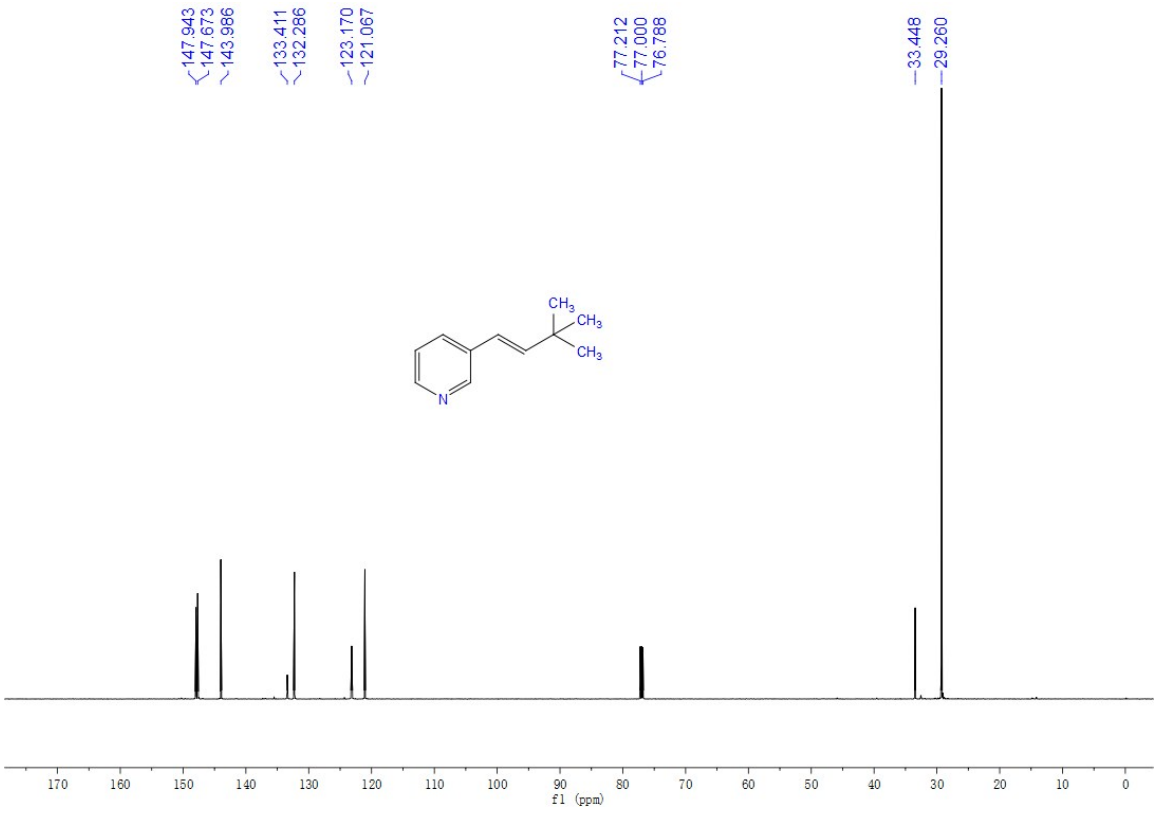
1.02
1.02
1.01
1.00
1.01
9.00
f1 (ppm)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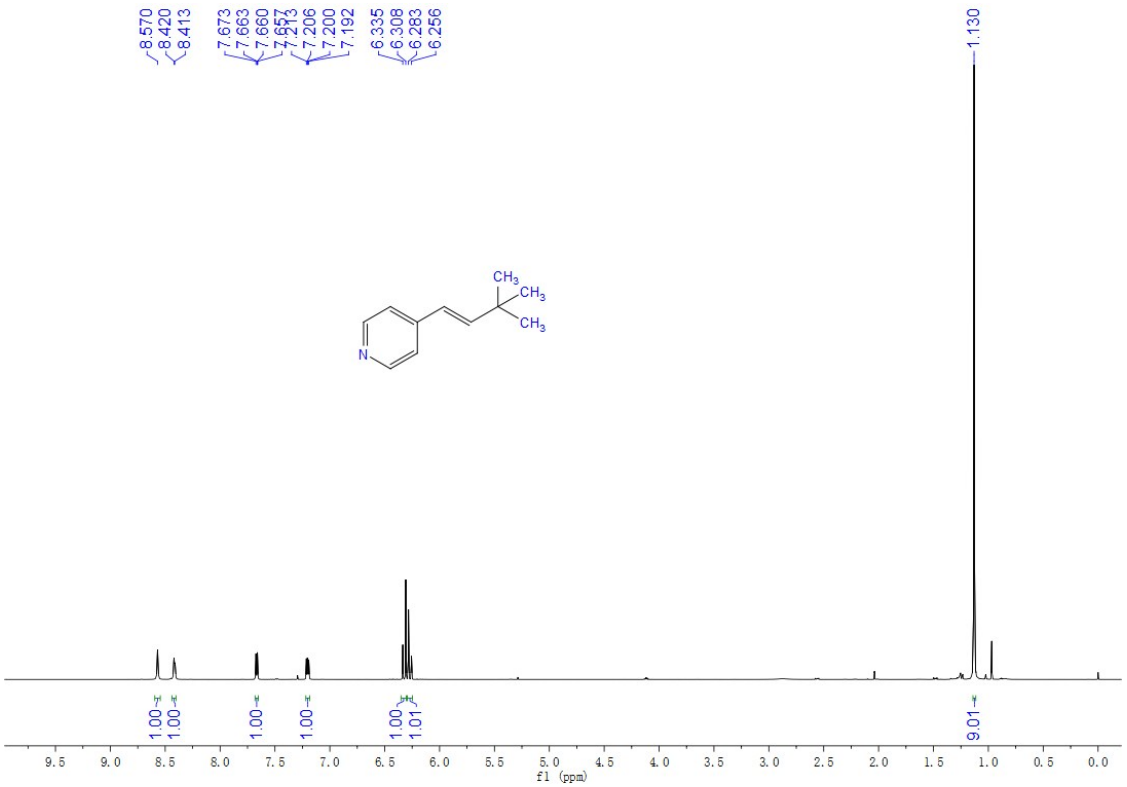
CH3
CH3
CH3
N
f1 (ppm)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6.308
6.283
6.256
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CH3
N
1.00
1.00
1.00
1.00
1.00
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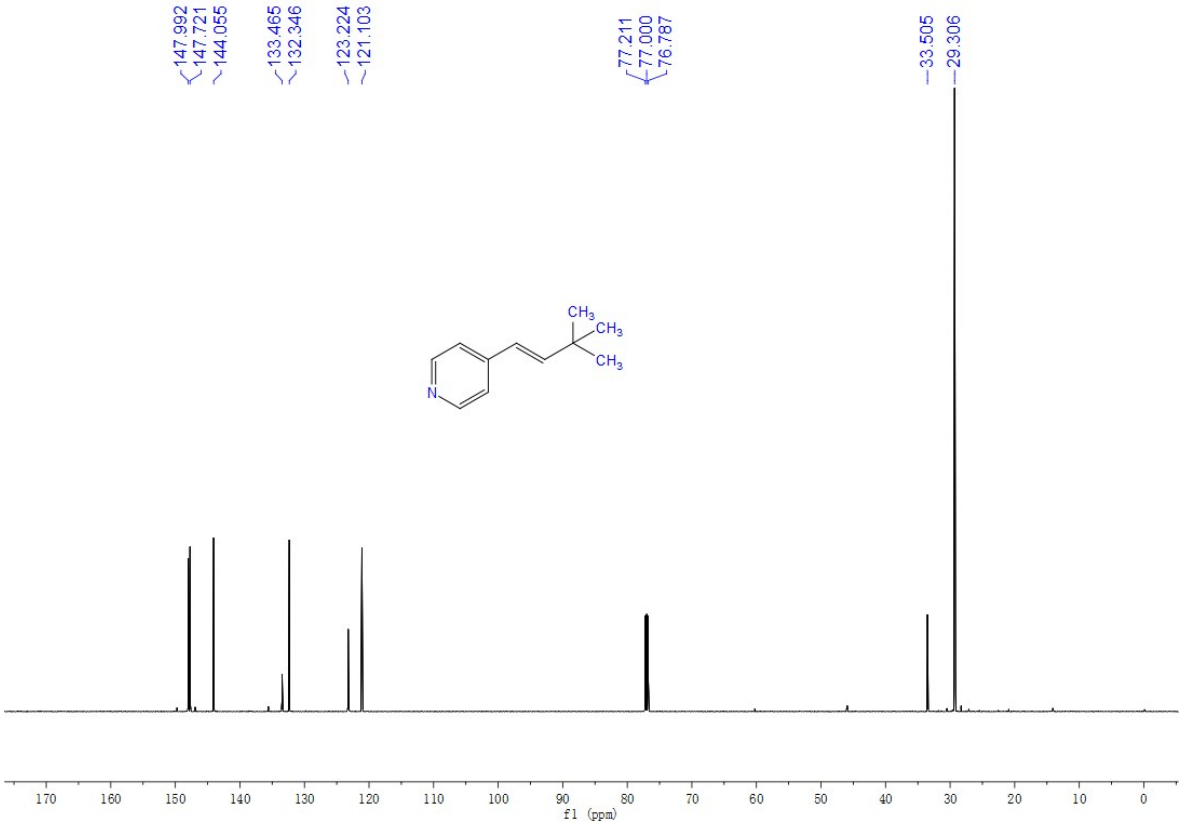
9.01
f1 (ppm)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33.505
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CH3
CH3
CH3
N
f1 (ppm)


8.545
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7.662
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7.656
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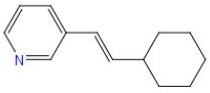
1.173
1.168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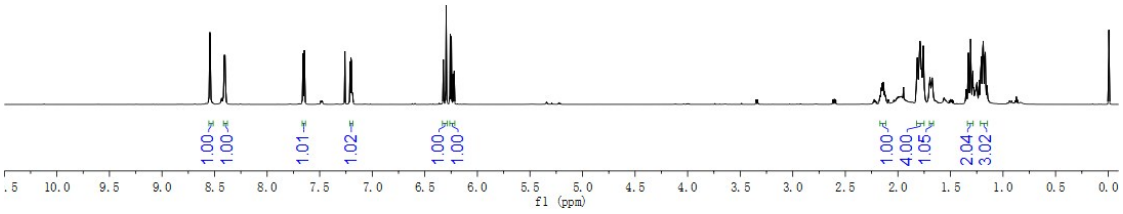
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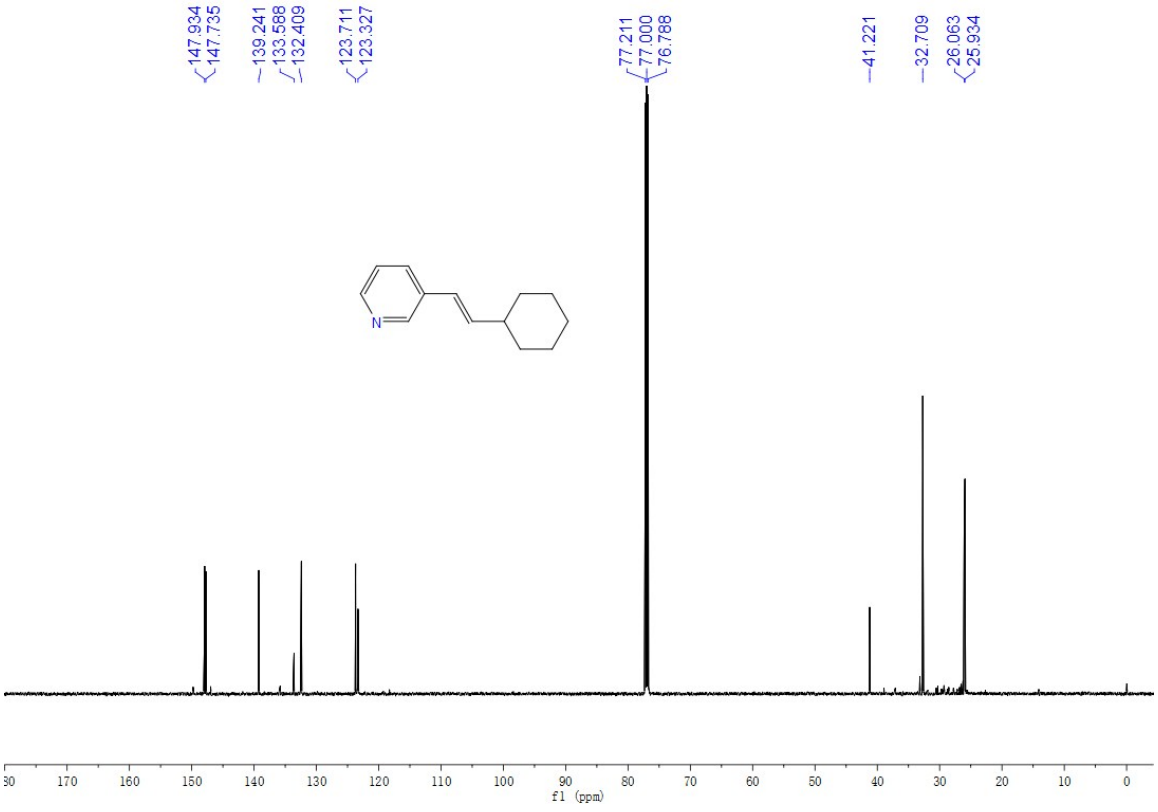
1.02
1.00
1.00
1.00
4.00
1.05
2.04
3.02
f1 (ppm)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147.735
139.241
133.588
132.409
123.711
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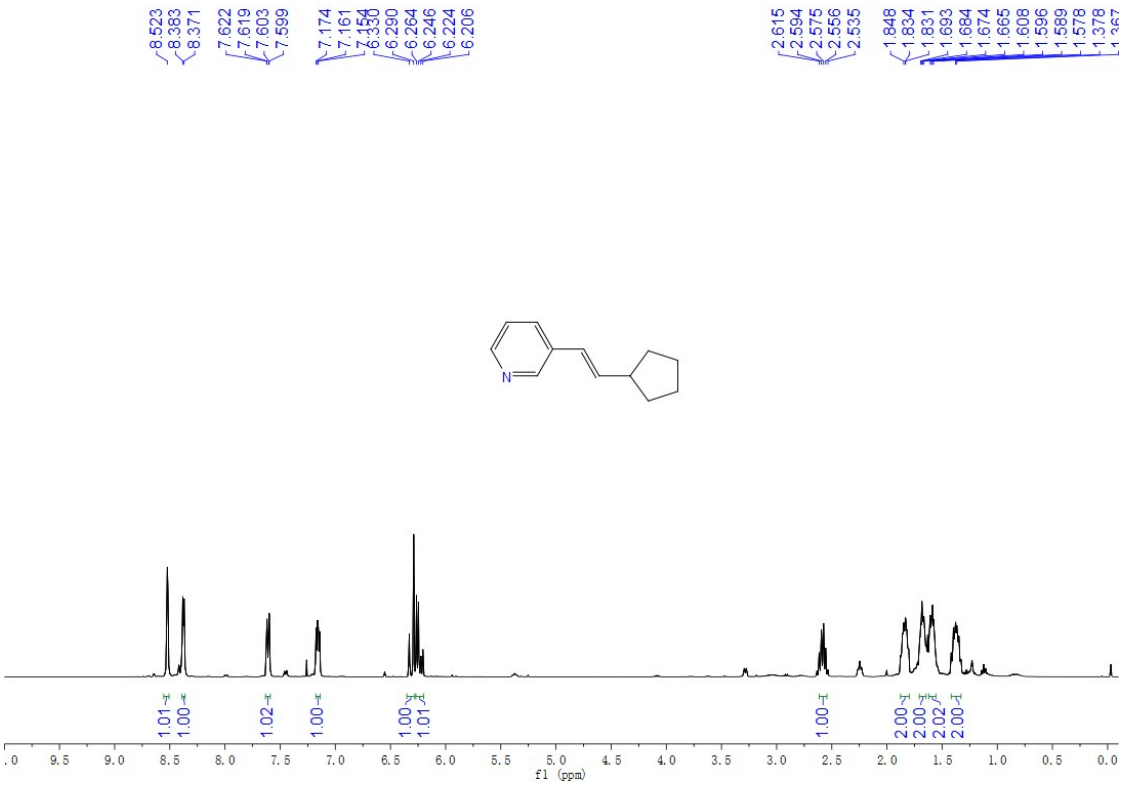
77.211
77.000
76.788
41.221
32.709
26.063
25.934
N
f1 (ppm)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8.371
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7.603
7.599
7.174
7.161
7.154
6.330
6.290
6.264
6.246
6.224
6.206
2.615
2.594
2.575
2.556
2.535
1.848
1.834
1.831
1.693
1.684
1.674
1.665
1.608
1.596
1.589
1.578
1.378
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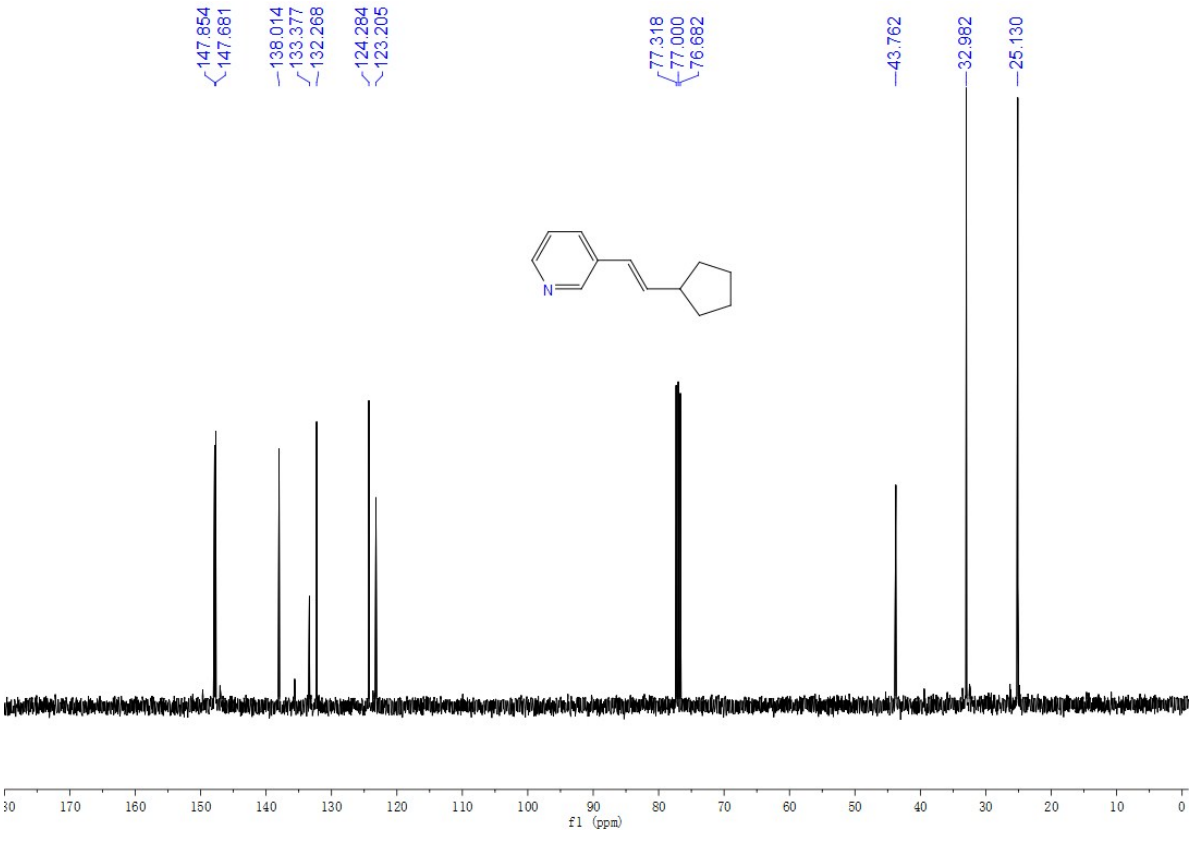
1.01
1.00
2.00
2.00
2.02
2.00
f1 (ppm)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138.014
133.377
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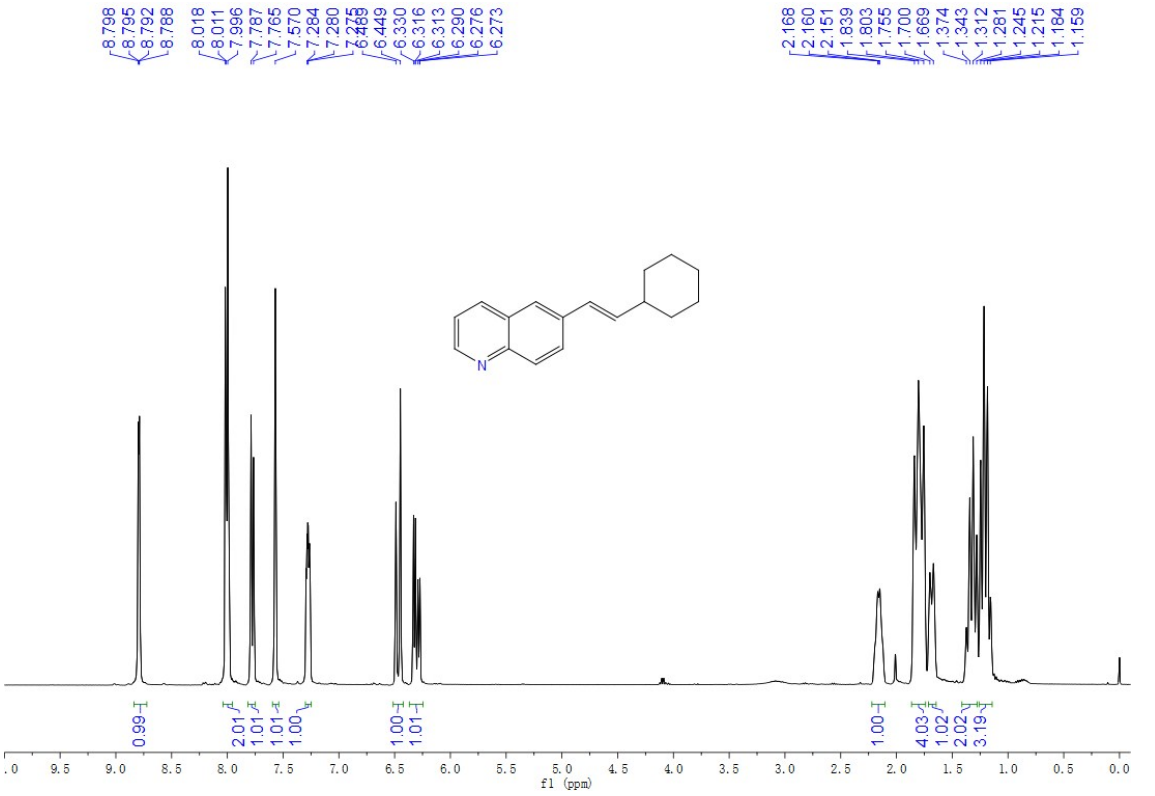
124.284
123.205
77.318
77.000
76.682
43.762
32.982
25.130
f1 (ppm)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8.011
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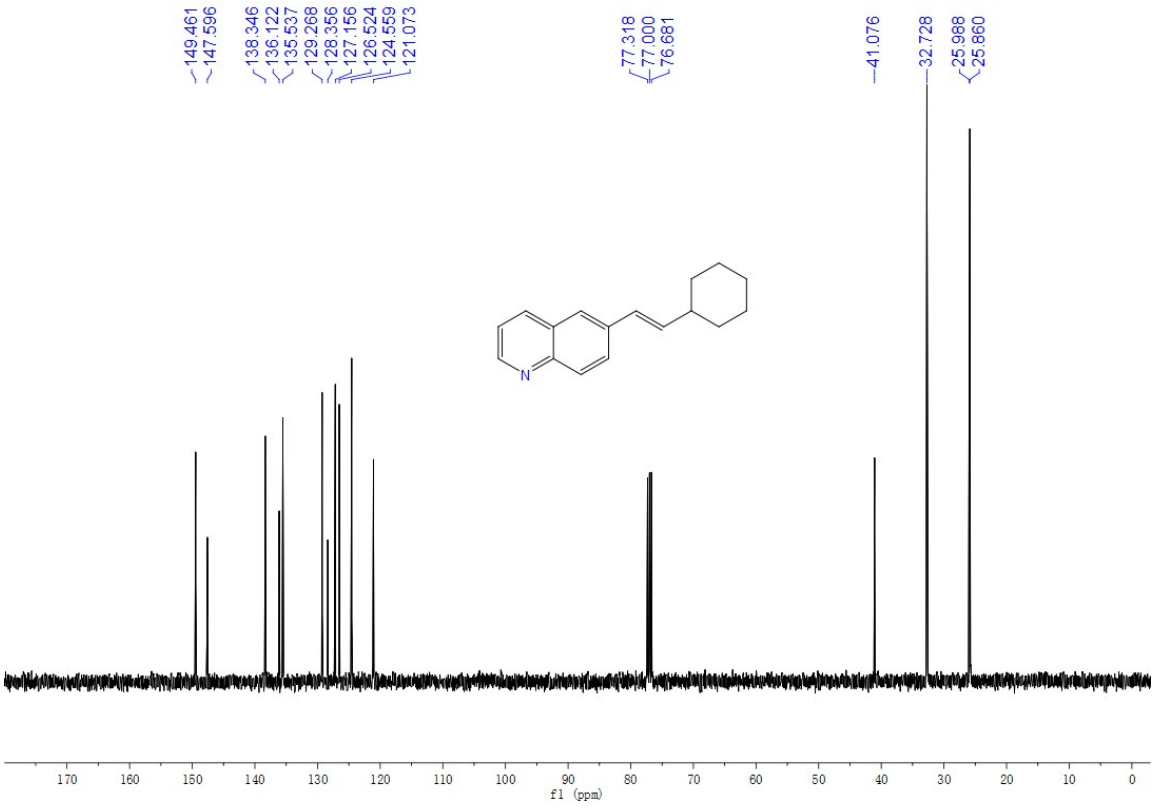
7.284
7.280
7.275
6.449
6.330
6.316
6.313
6.290
6.276
6.273
2.168
2.160
2.151
1.839
1.803
1.755
1.700
1.669
1.374
1.343
1.312
1.281
1.245
1.215
1.184
1.159
0.99
2.01
1.01
1.01
1.00
1.00
1.01
1.00
4.03
1.02
2.02
3.19
f1 (ppm)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129.268
128.356
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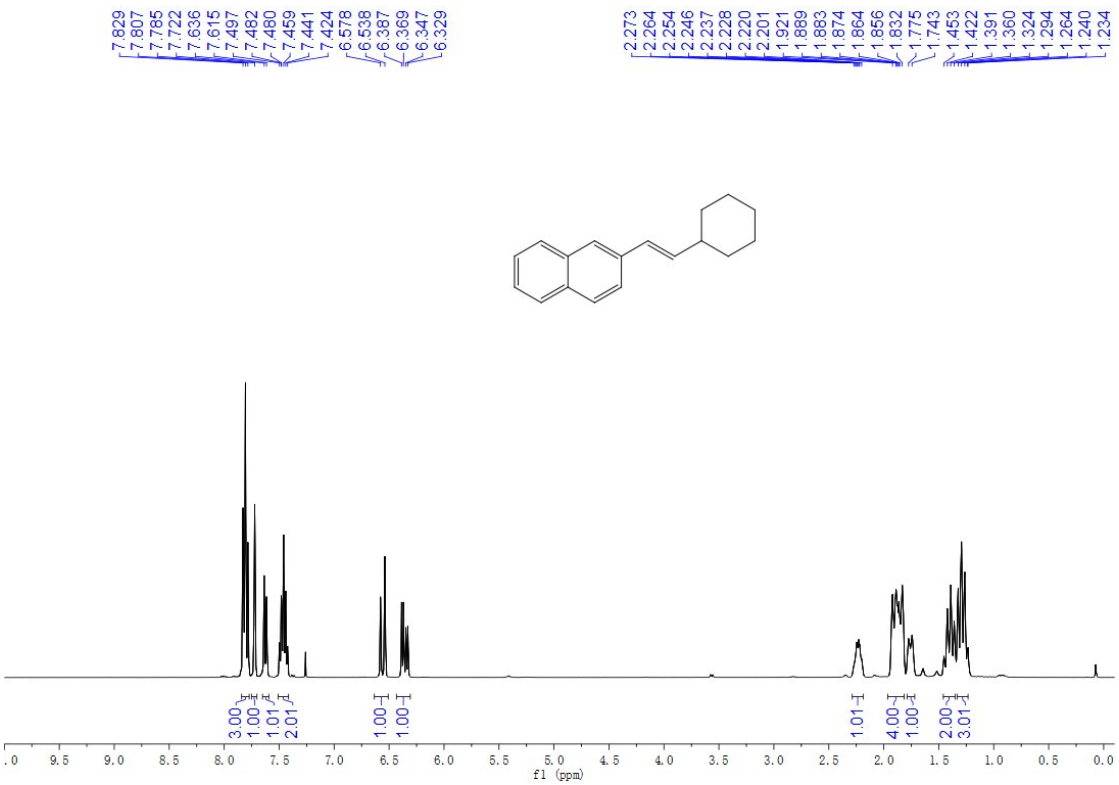
121.073
77.318
77.000
76.681
41.076
32.728
25.988
25.860
f1 (ppm)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7.722
7.636
7.615
7.497
7.482
7.480
7.459
7.441
7.424
6.578
6.538
6.387
6.369
6.347
6.329
2.273
2.264
2.254
2.246
2.237
2.228
2.220
2.201
1.921
1.889
1.883
1.874
1.864
1.856
1.832
1.775
1.743
1.453
1.422
1.391
1.360
1.324
1.294
1.264
1.240
1.234
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1.00
1.01
2.01
1.00
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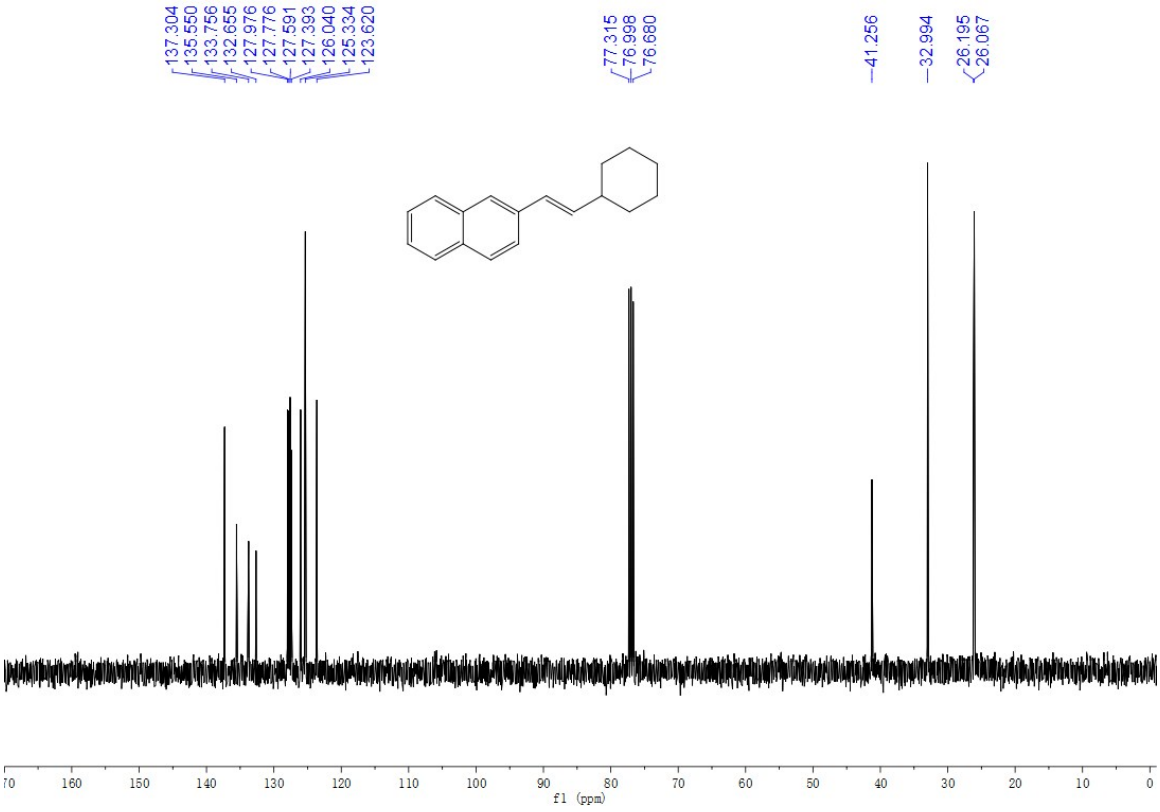
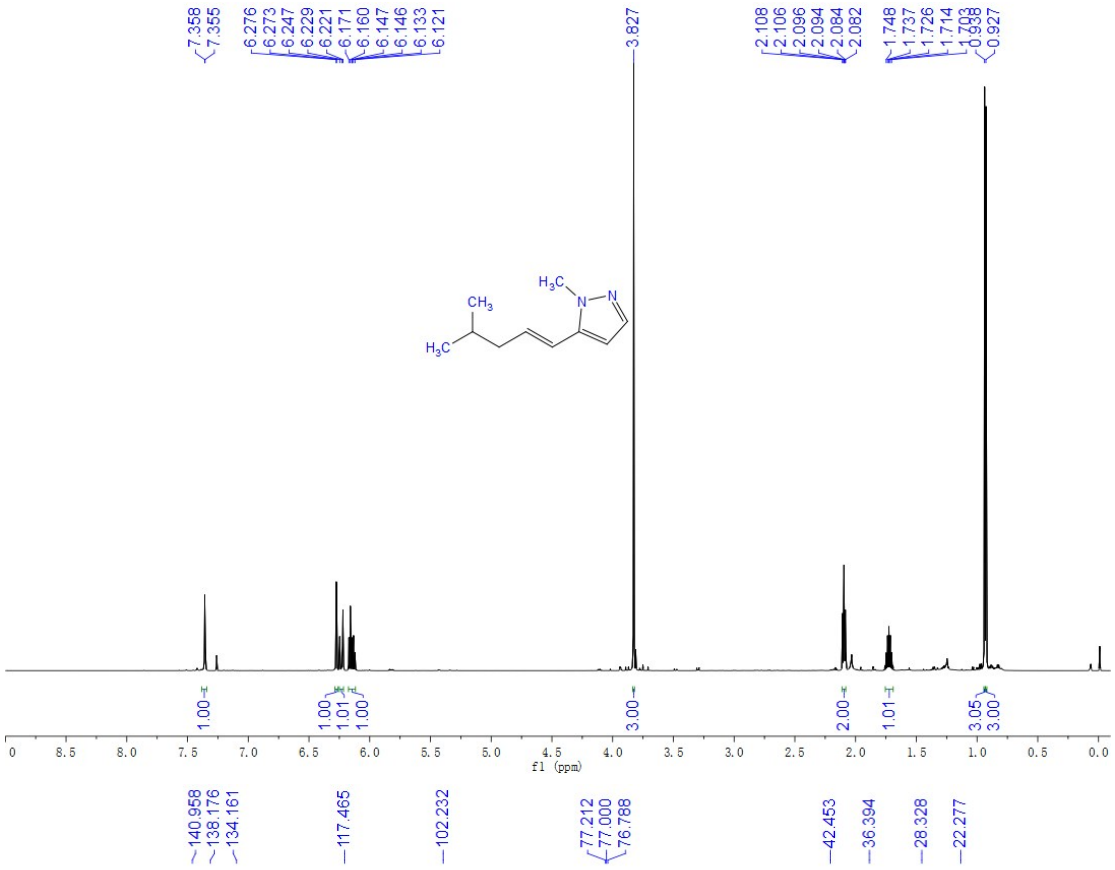
4.00
1.00
2.00
3.01
f1 (ppm)


137.304
135.550
133.756
132.655
127.976
127.776
127.591
127.393
126.040
125.334
123.620
77.315
76.998
76.680
41.256
32.994
26.195
26.067
f1 (ppm)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7.355
6.276
6.273
6.247
6.229
6.221
6.171
6.160
6.147
6.146
6.133
6.121
3.827
2.108
2.106
2.096
2.094
2.084
2.082
1.748
1.737
1.726
1.714
1.703
0.938
0.927
1.00
1.00
1.01
1.00
3.00
2.00
1.01
3.05
3.00
f1 (ppm)
140.958
138.176
134.161
117.465
102.232
77.212
77.000
76.788
42.453
36.394
28.328
22.277
f1 (ppm)


7.260
5.399
5.396
5.393
5.390
5.388
5.384
5.381
1.970
1.968
1.963
1.961
1.958
1.952
1.949
1.946
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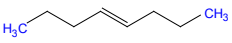
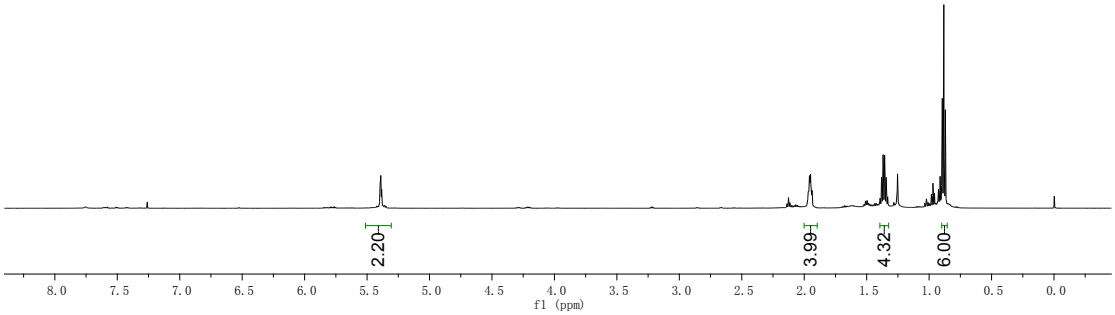
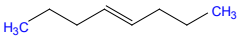
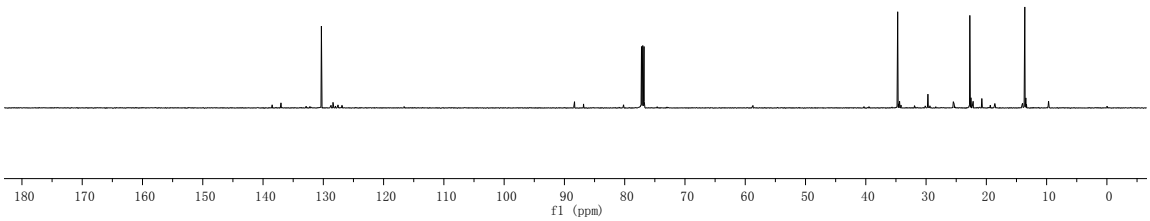
1.356
1.332
0.894
0.882
0.870

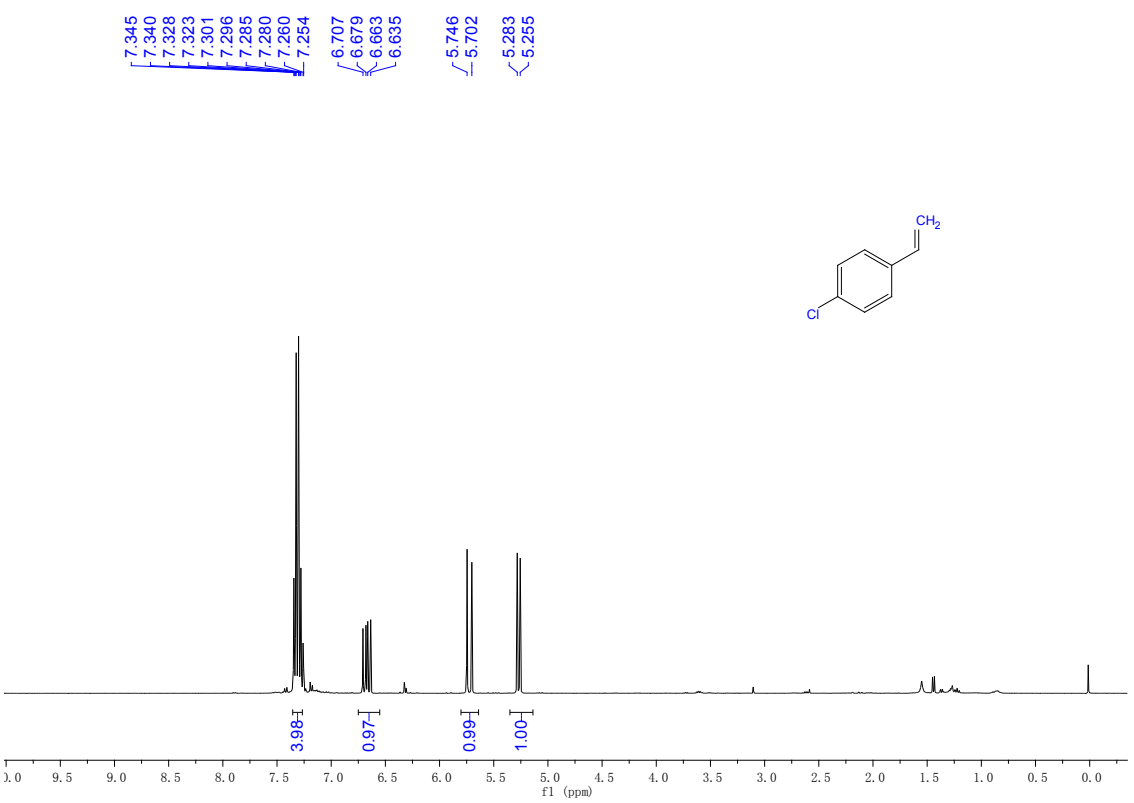

H3C
CH3


2.20
3.99
4.32
6.00
f1 (ppm)


130.319
77.211
77.000
76.788
34.711
22.742
13.622


H3C
CH3


f1 (ppm)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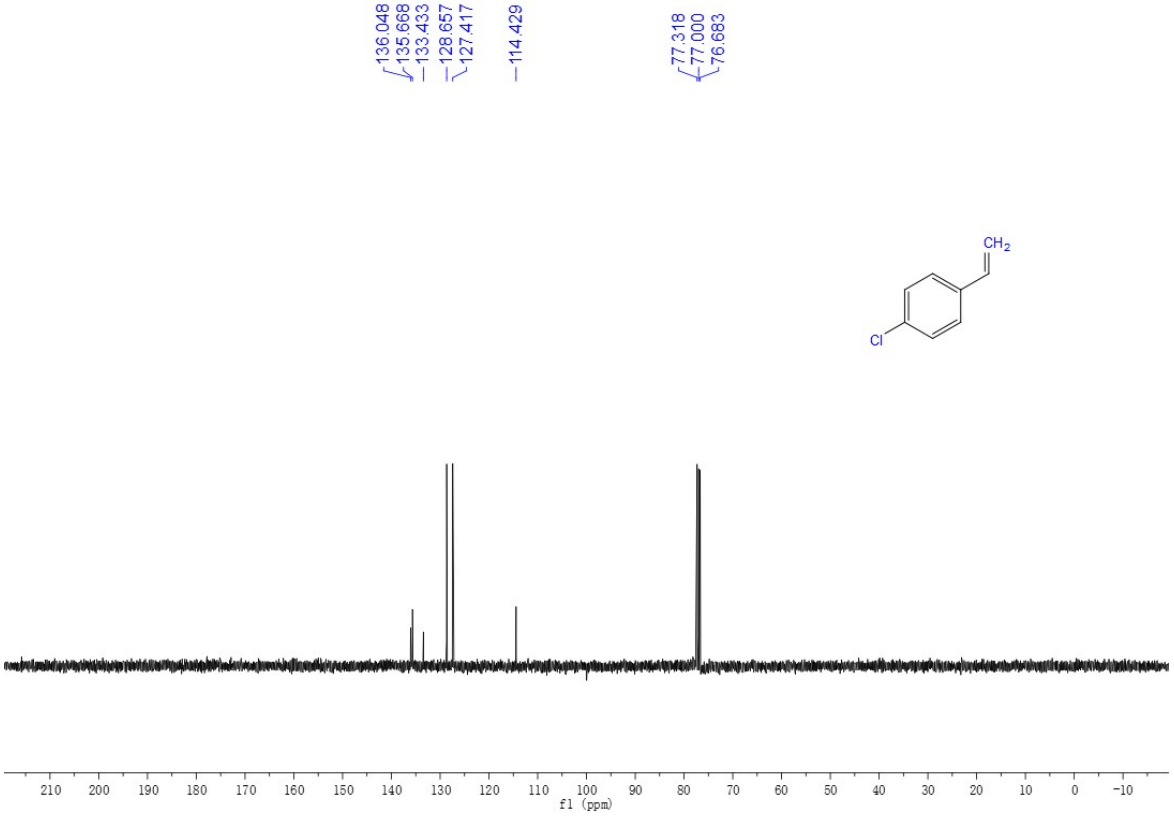
7.328
7.323
7.301
7.296
7.285
7.280
7.260
7.254
6.707
6.679
6.663
6.635
5.746
5.702
5.283
5.255
CH2
Cl
3.98
0.97
0.99
1.00
f1 (ppm)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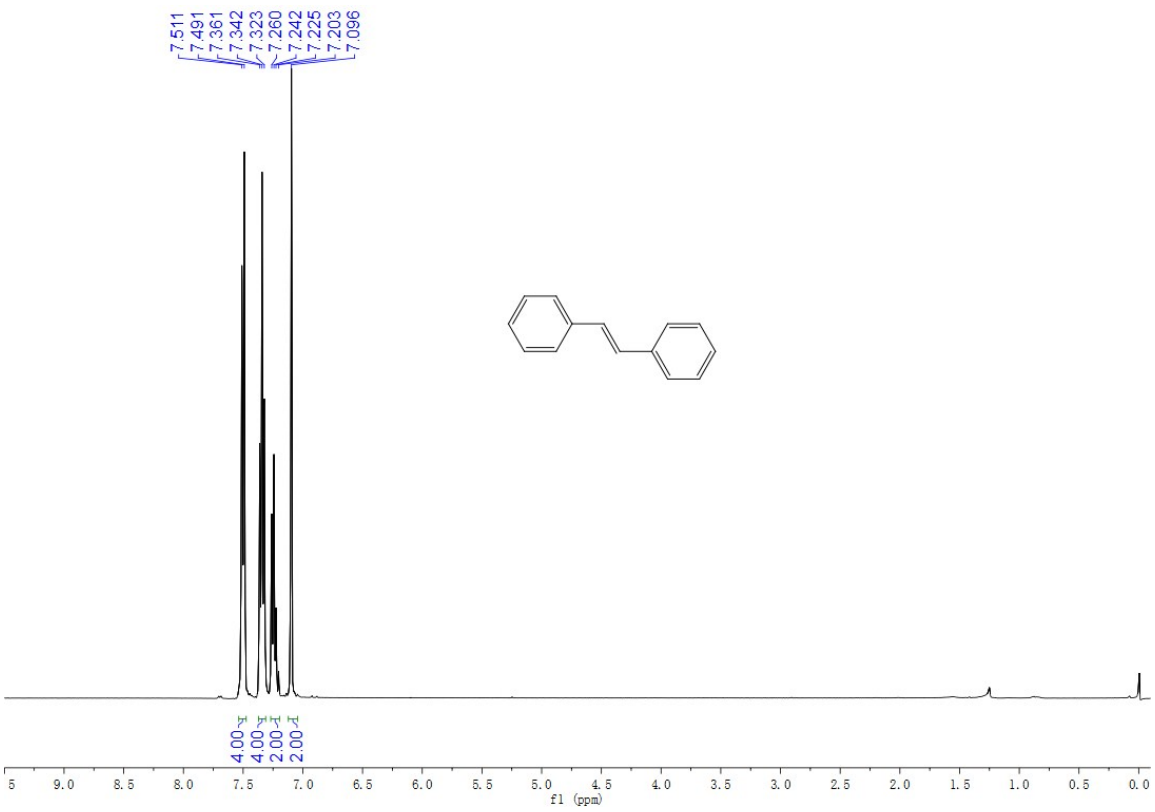
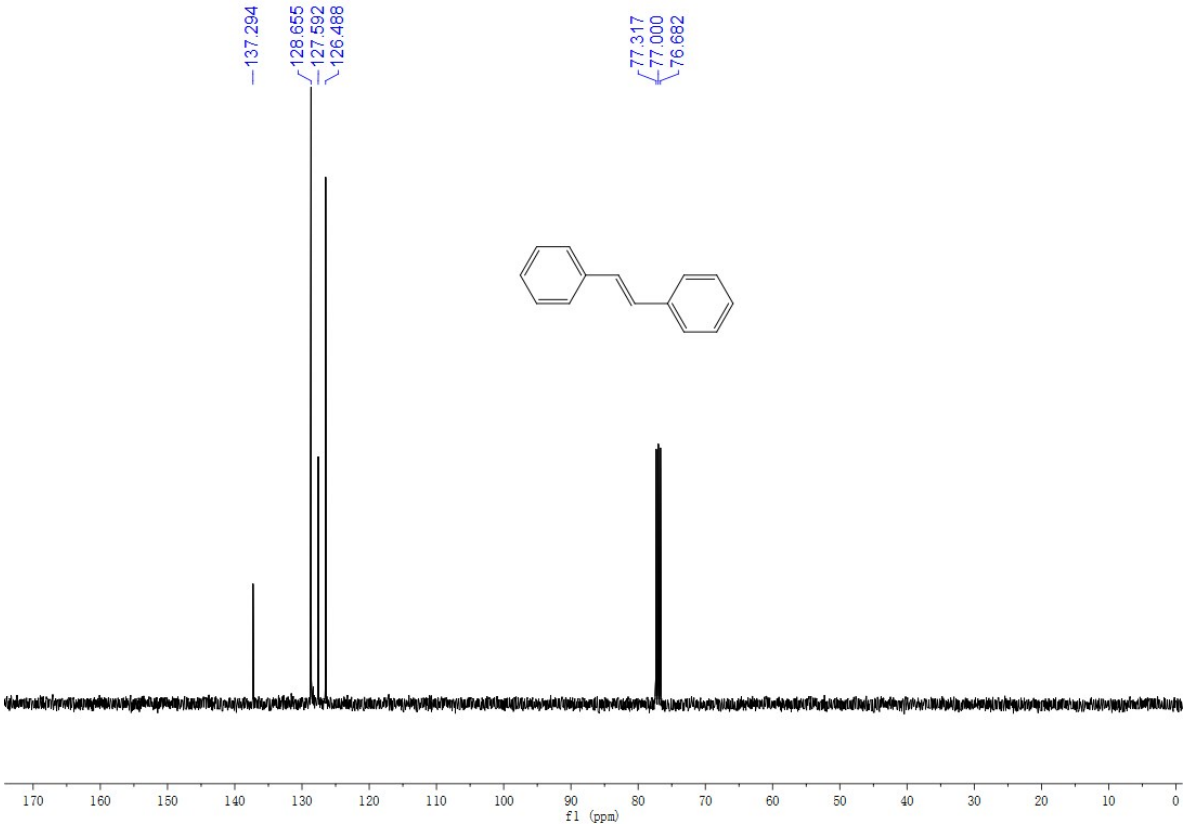
128.657
127.417
114.429
77.318
77.000
76.683
CH2
Cl
f1 (ppm)


7.511
7.491
7.361
7.342
7.323
7.260
7.242
7.225
7.203
7.096
4.00
4.00
2.00
2.00
f1 (ppm)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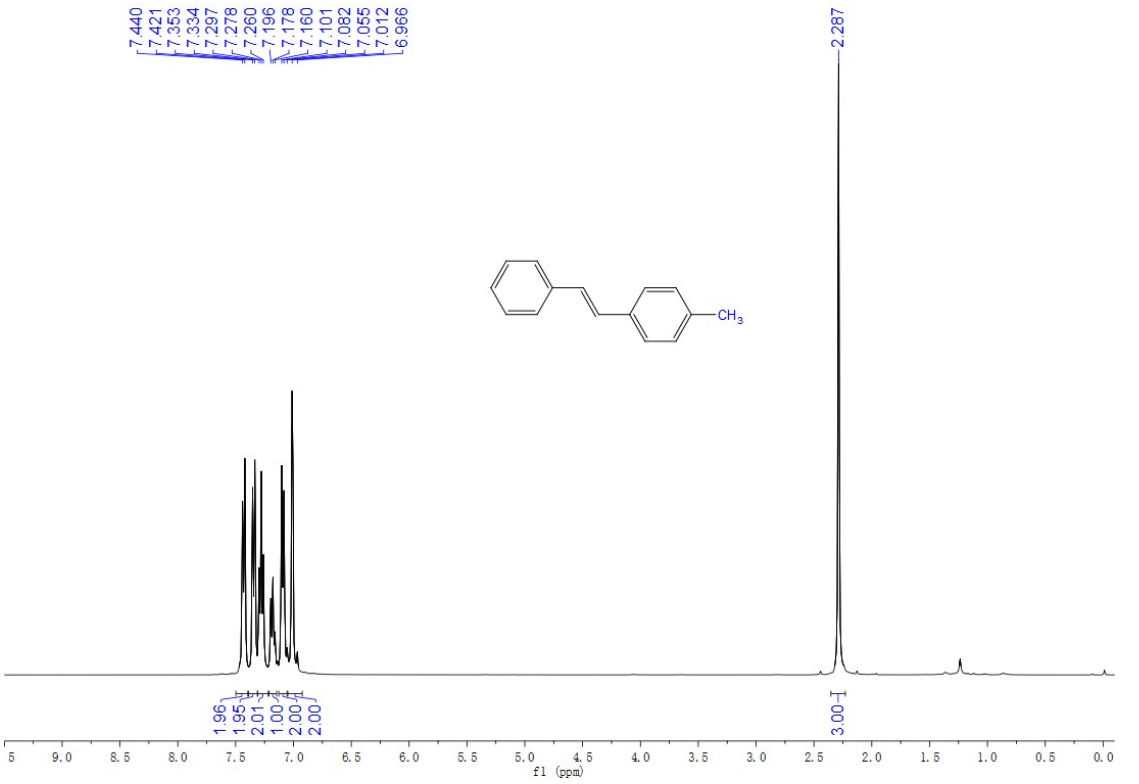
128.655
127.592
126.488
77.317
77.000
76.682
f1 (ppm)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7.421
7.353
7.334
7.297
7.278
7.260
7.196
7.178
7.160
7.101
7.082
7.055
7.012
6.966
2.287
CH3
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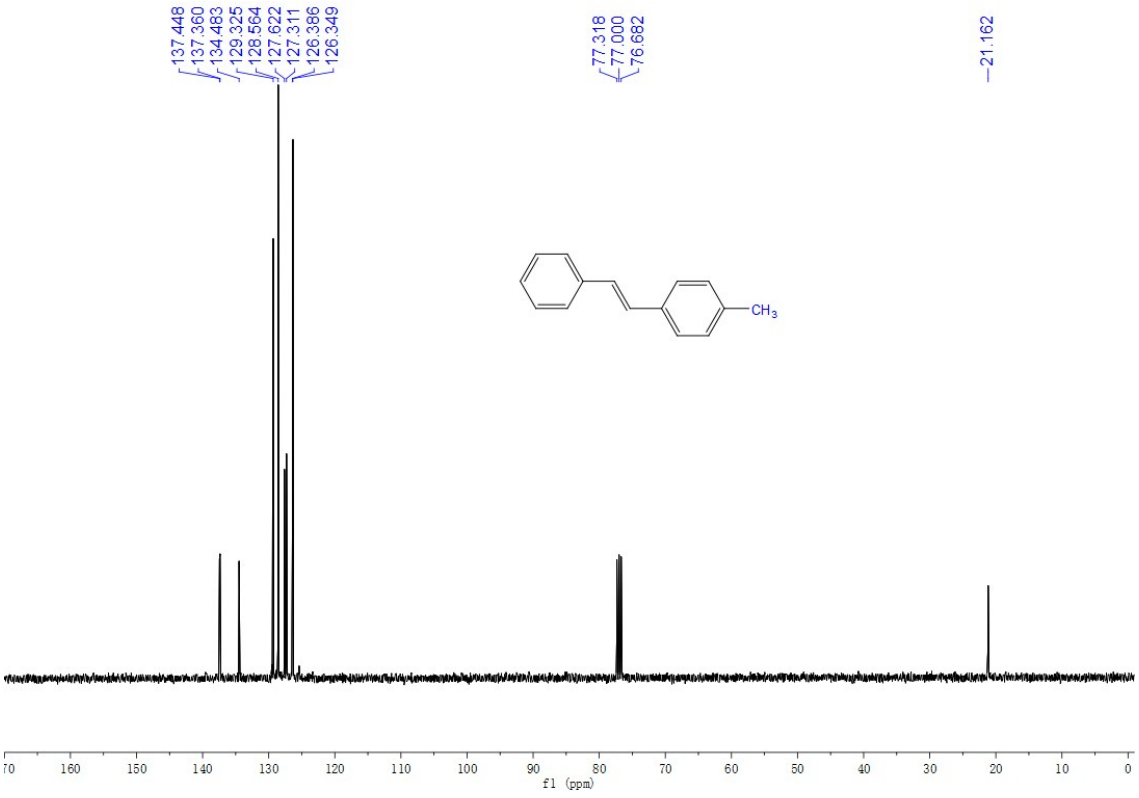
1.95
2.01
1.00
2.00
2.00
3.00
f1 (ppm)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137.360
134.483
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126.349
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77.000
76.682
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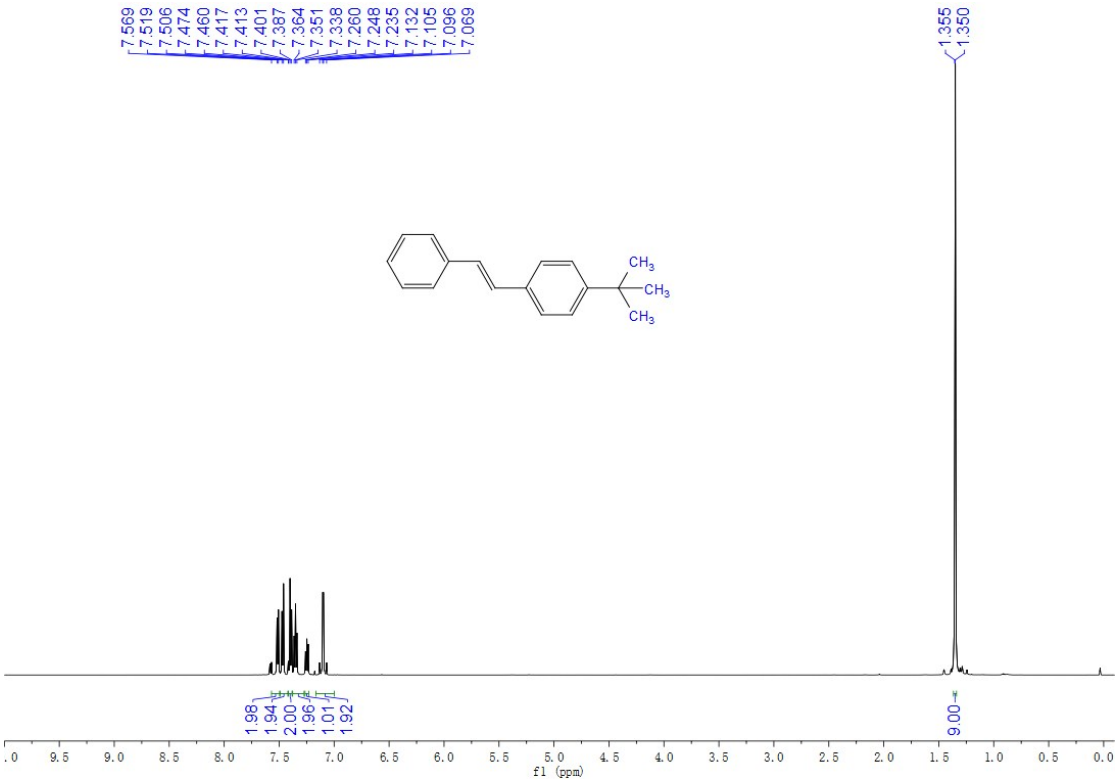
f1 (ppm)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7.506
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7.460
7.417
7.413
7.401
7.387
7.364
7.351
7.338
7.260
7.248
7.235
7.132
7.105
7.096
7.069
1.355
1.350
CH3
CH3
CH3
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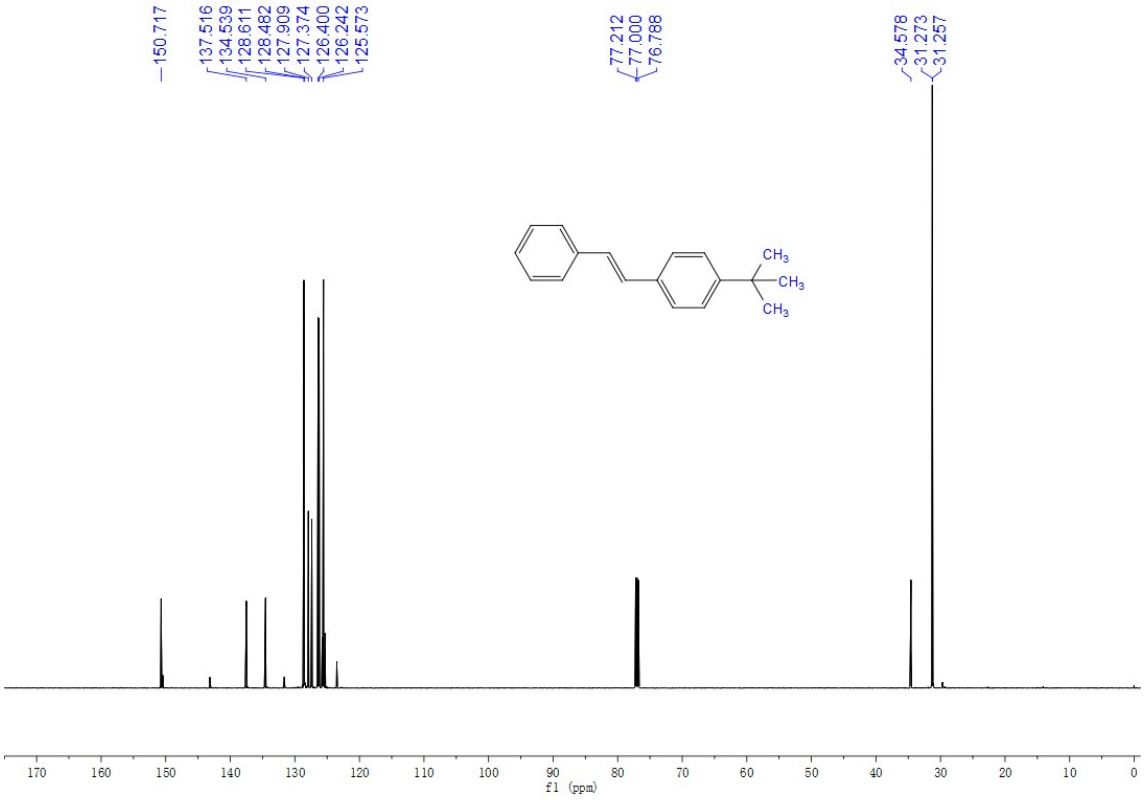
1.94
2.00
1.96
1.01
1.92
9.00
f1 (ppm)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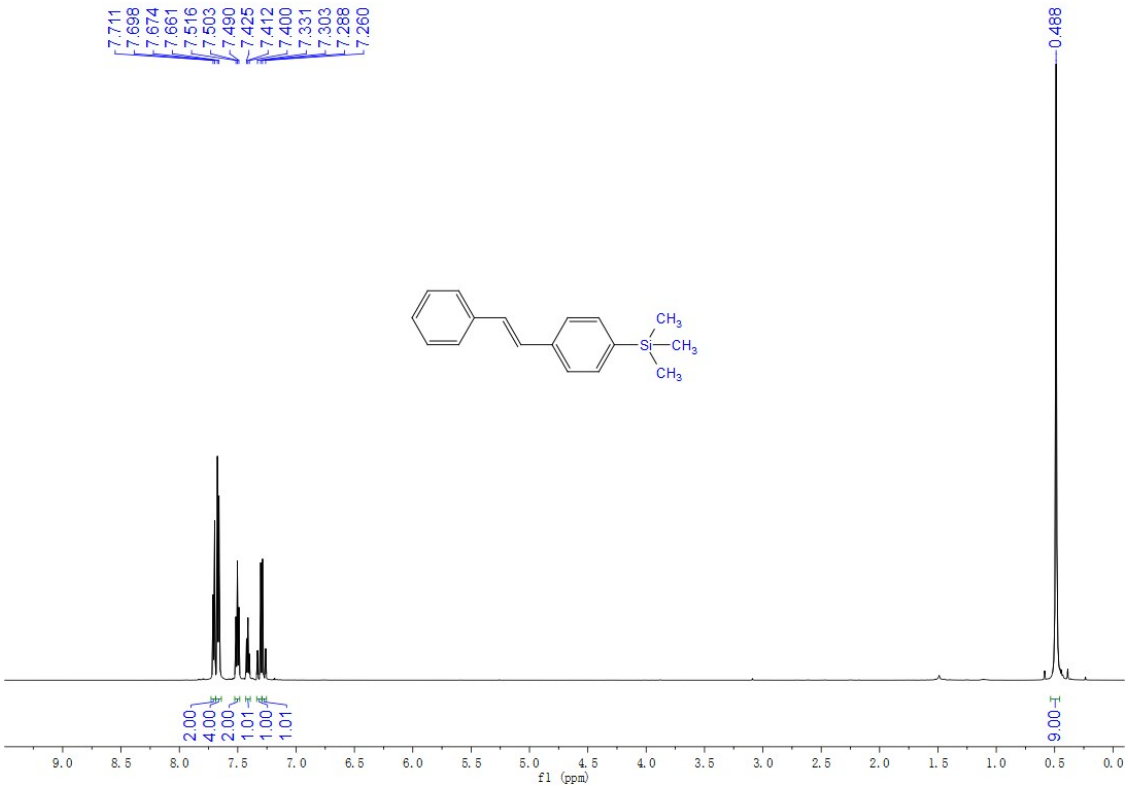
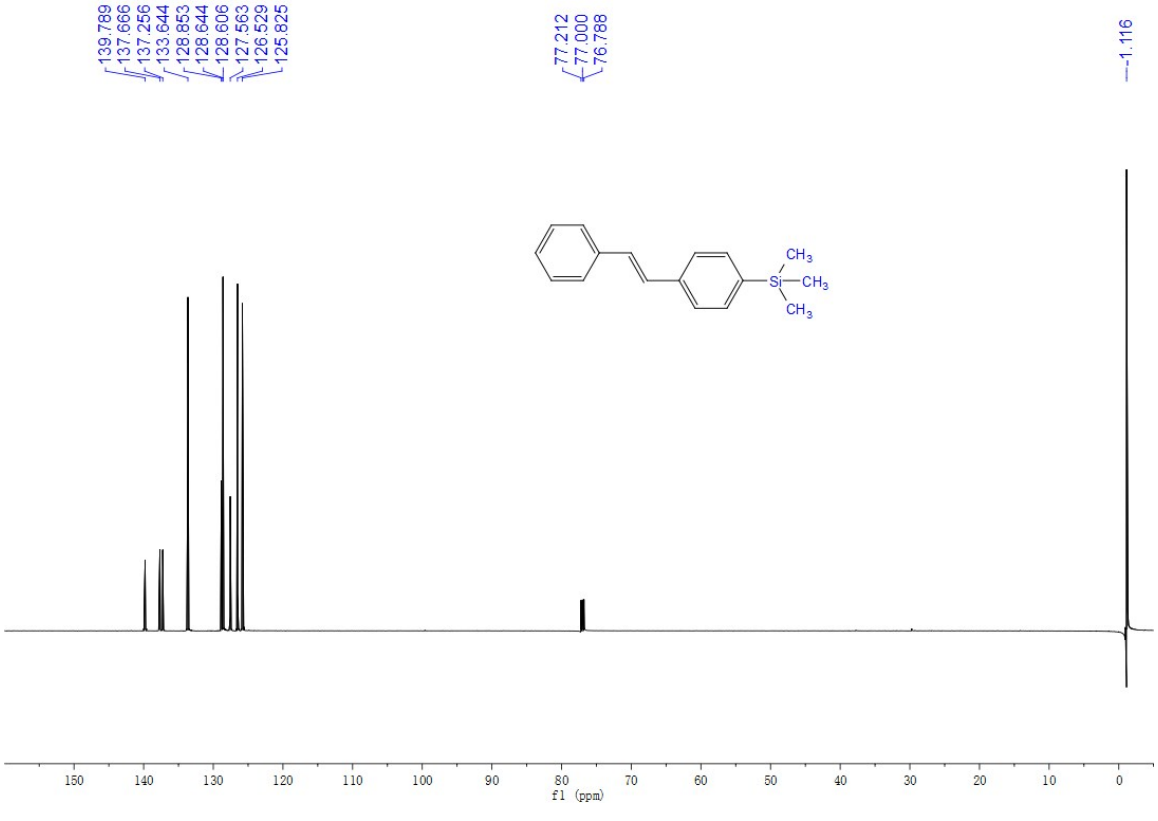
127.909
127.374
126.400
126.242
125.573
77.212
77.000
76.788
34.578
31.273
31.257
CH3
CH3
CH3
f1 (ppm)


7.711
7.698
7.674
7.661
7.516
7.503
7.490
7.425
7.412
7.400
7.331
7.303
7.288
7.260
0.488
CH3
Si
CH3
CH3
2.00
4.00
2.00
1.01
1.00
1.01
9.00
f1 (ppm)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127.563
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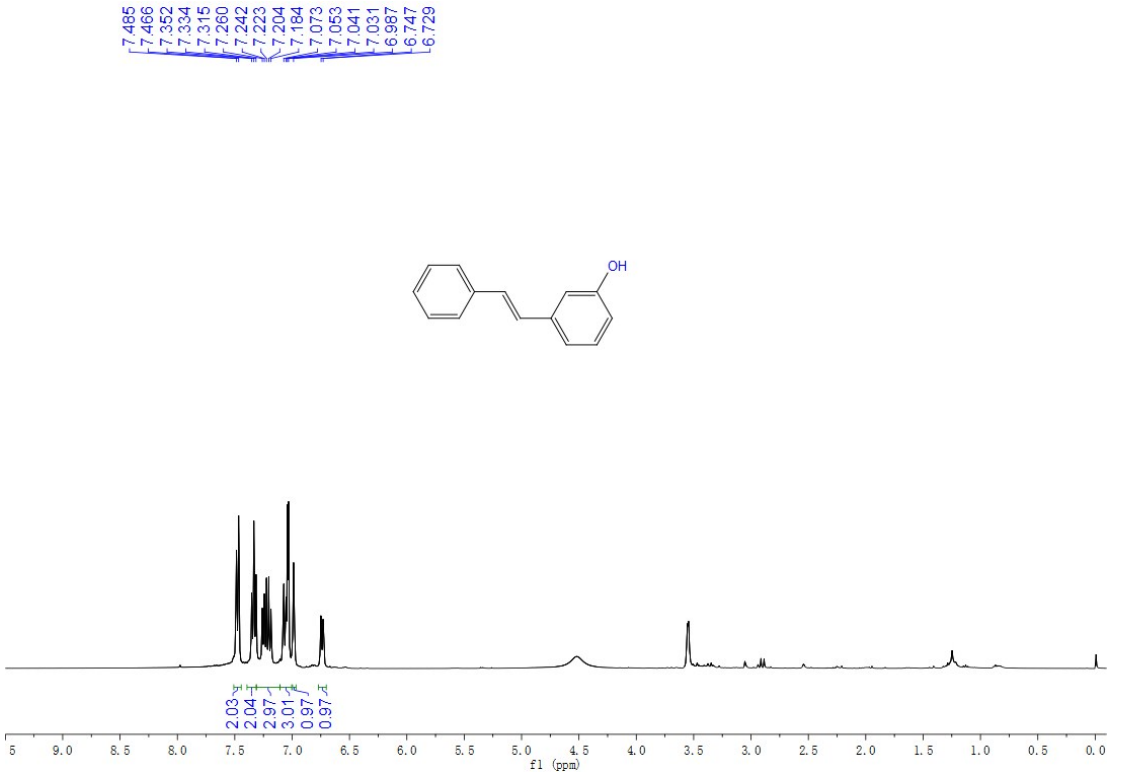
125.825
77.212
77.000
76.788
1.116
CH3
Si
CH3
CH3
f1 (ppm)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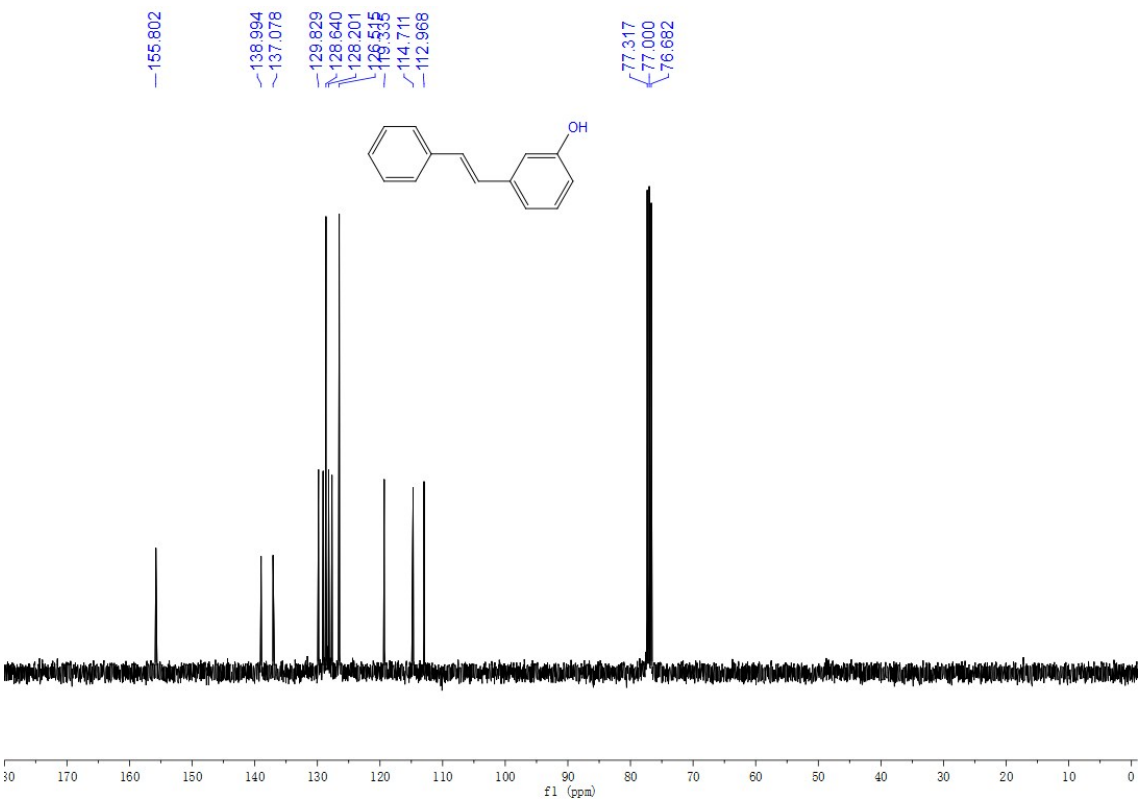
7.334
7.315
7.260
7.242
7.223
7.204
7.184
7.073
7.053
7.041
7.031
6.987
6.747
6.729
OH
2.03
2.04
2.97
3.01
0.97
0.97
f1 (ppm)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128.201
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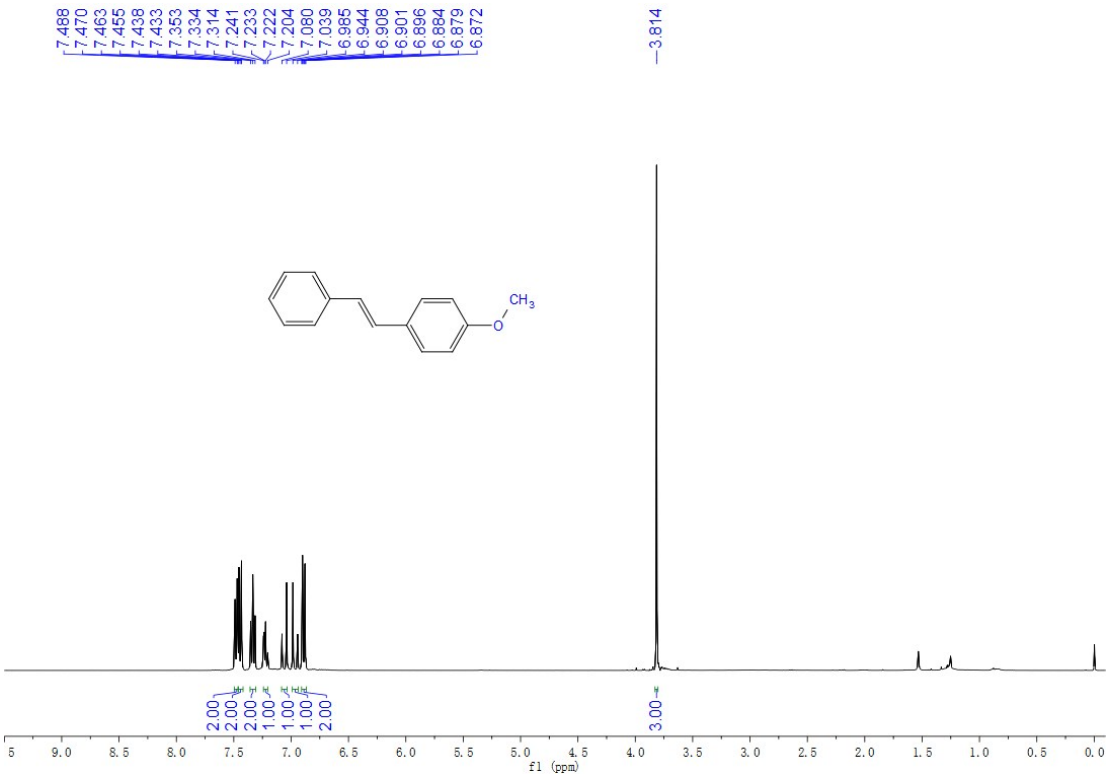
114.711
112.968
77.317
77.000
76.682
OH
f1 (ppm)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7.353
7.334
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7.241
7.233
7.222
7.204
7.080
7.039
6.985
6.944
6.908
6.901
6.896
6.884
6.879
6.872
3.814
CH3
O
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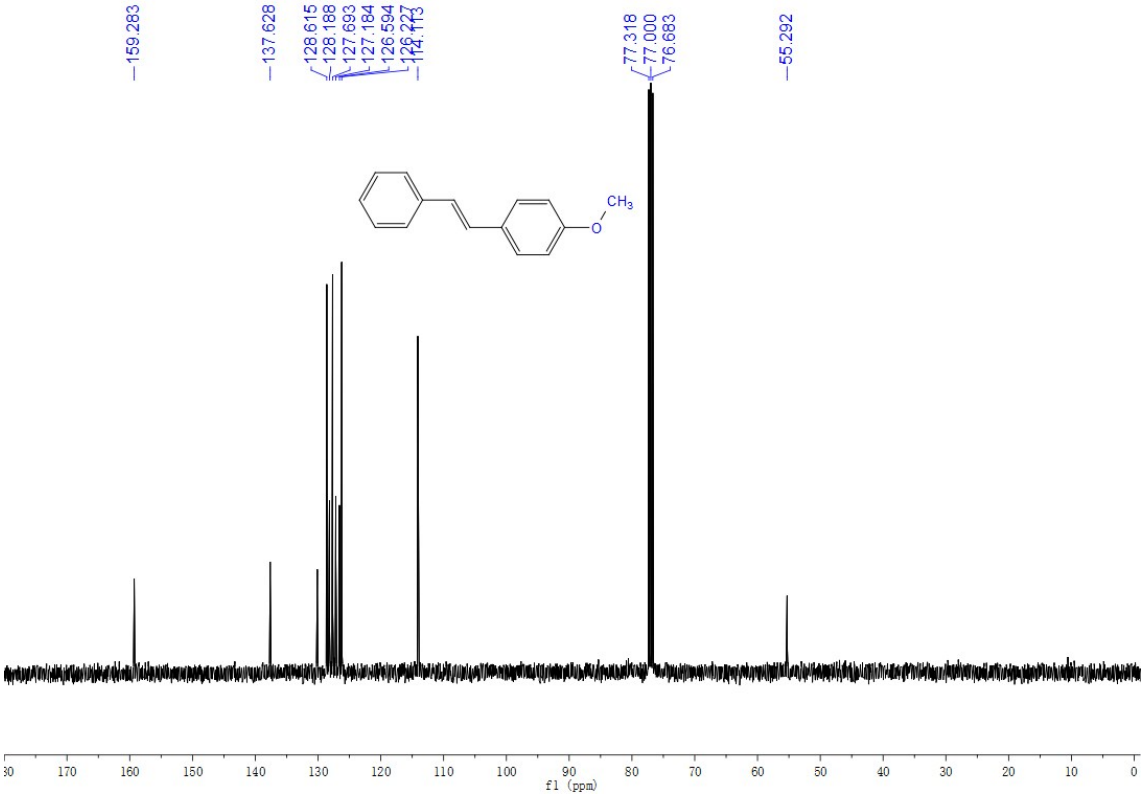
2.00
2.00
1.00
1.00
1.00
2.00
3.00
f1 (ppm)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126.227
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77.000
76.683
55.292
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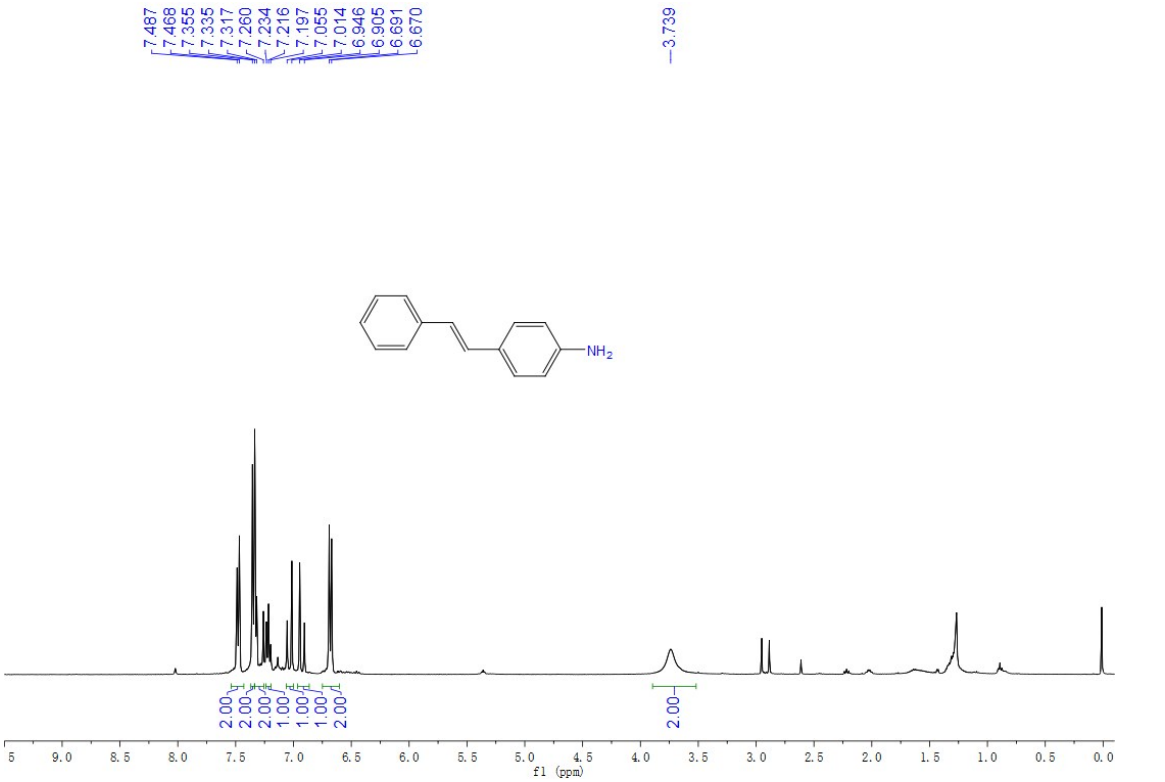
O
f1 (ppm)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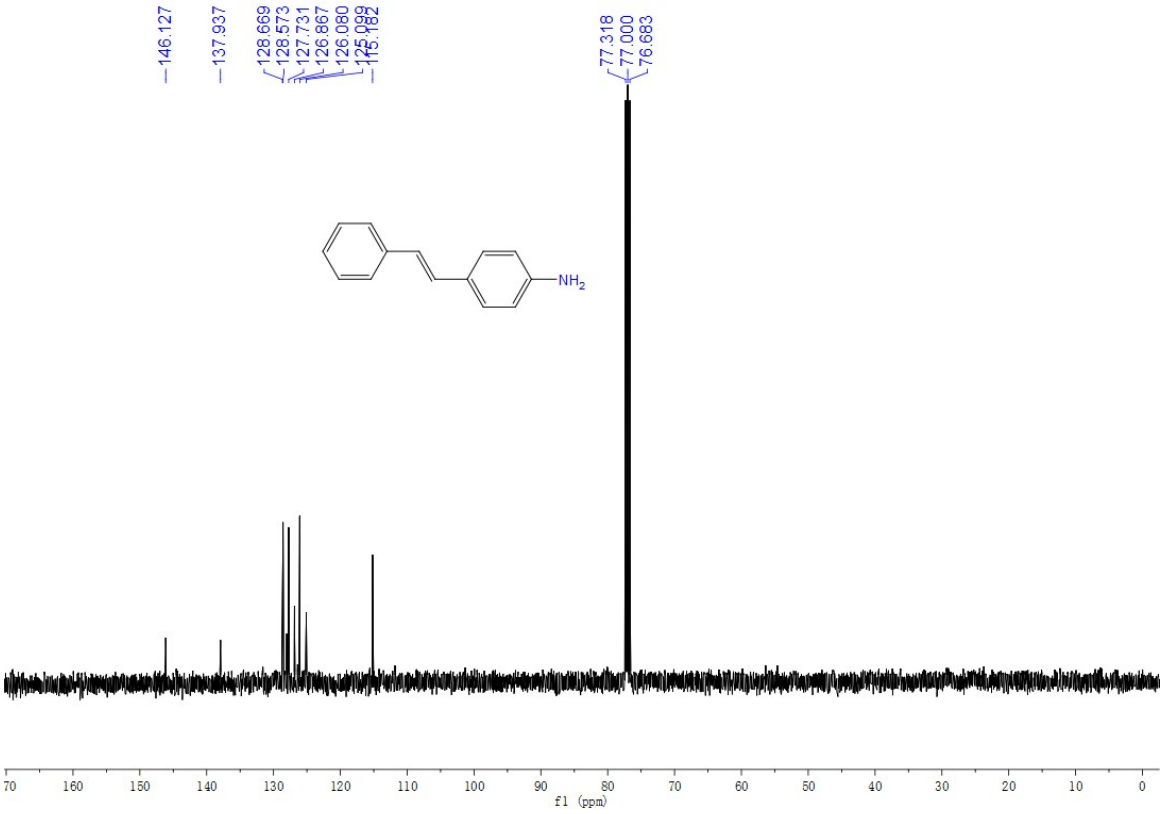
7.260
7.234
7.216
7.197
7.055
7.014
6.946
6.905
6.691
6.670
3.739
NH2
2.00
2.00
2.00
1.00
1.00
2.00
2.00
f1 (ppm)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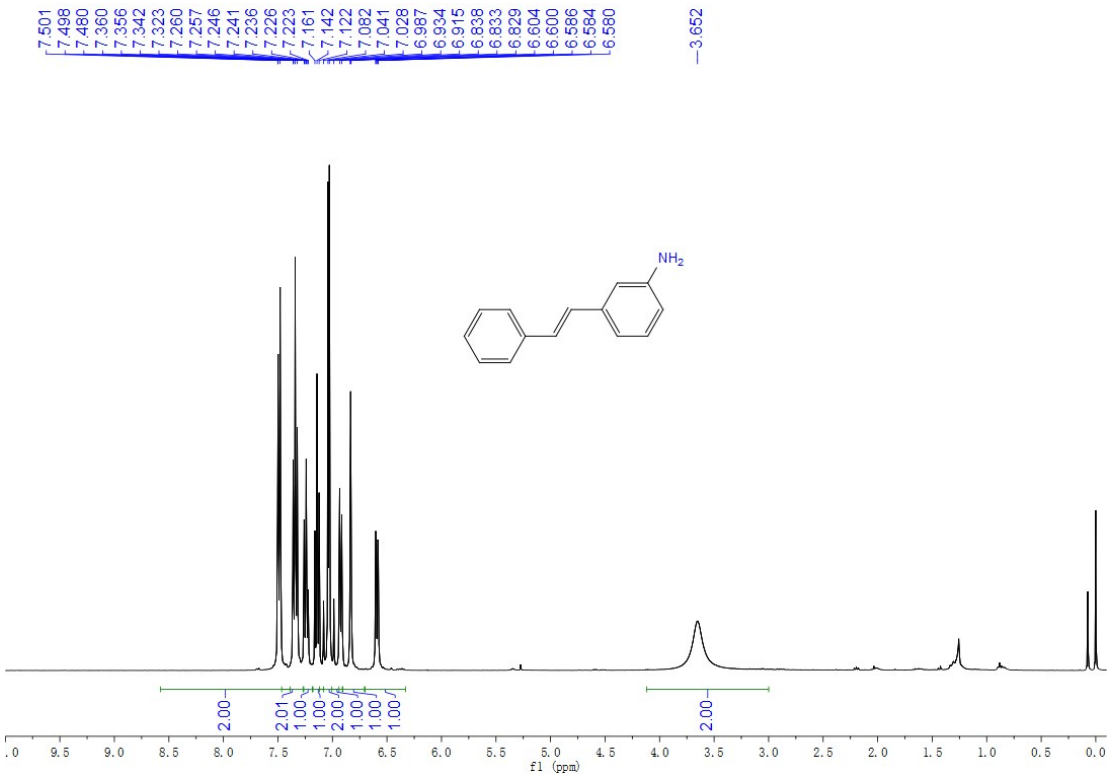
125.099
115.182
77.318
77.000
76.683
NH2
f1 (ppm)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7.480
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7.342
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7.260
7.257
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7.241
7.236
7.226
7.223
7.161
7.142
7.122
7.082
7.041
7.028
6.987
6.934
6.915
6.838
6.833
6.829
6.604
6.600
6.586
6.584
6.580
3.652
NH2
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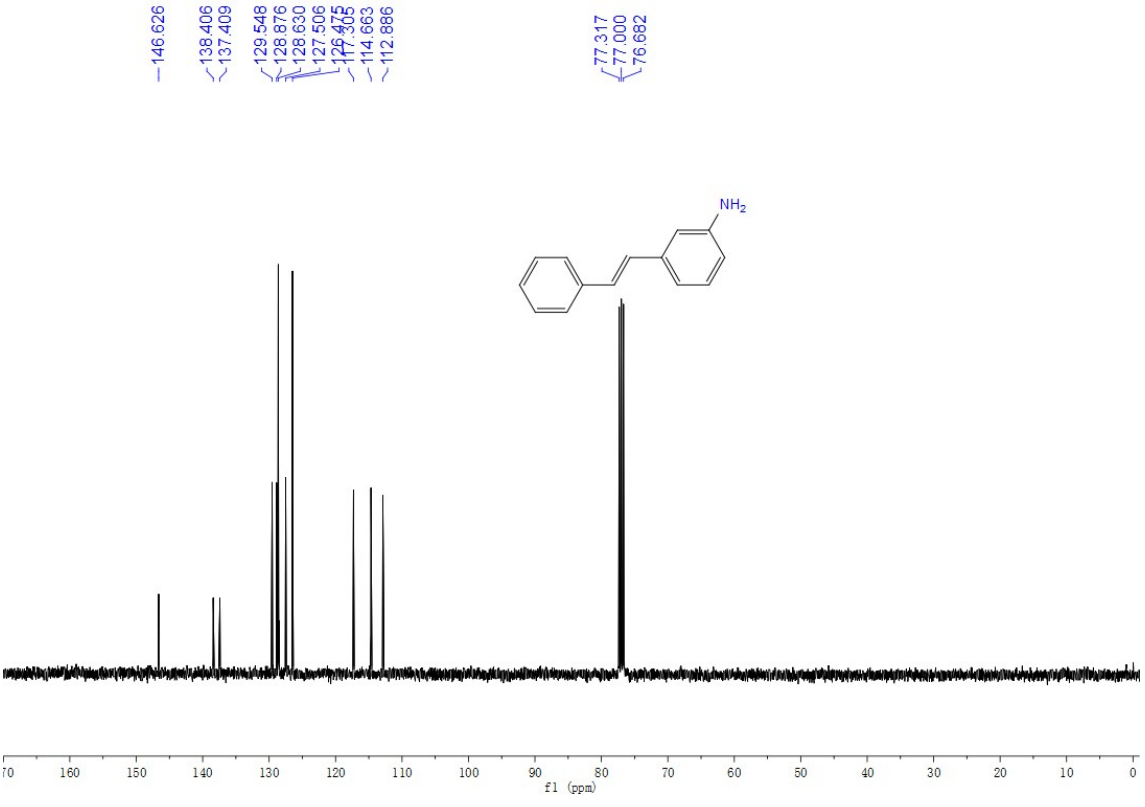
1.00
2.00
1.00
1.00
2.00
f1 (ppm)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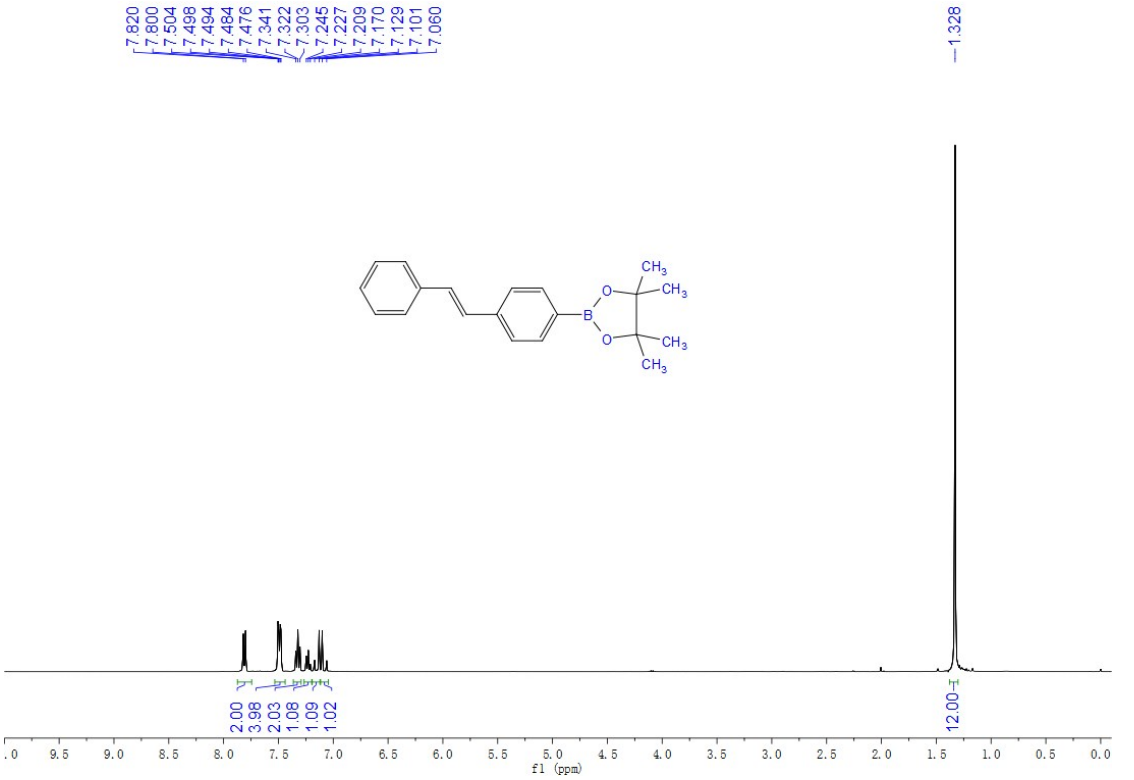
77.000
76.682
NH2
f1 (ppm)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7.209
7.170
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3.98
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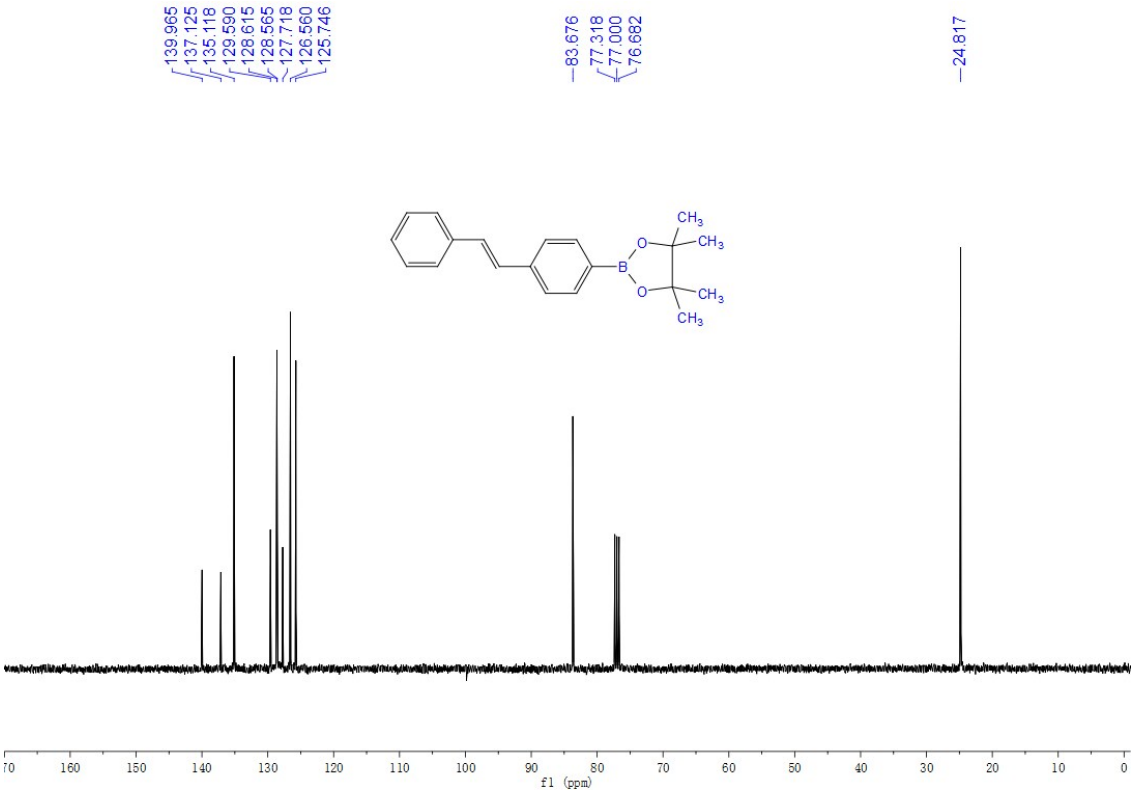
1.09
1.02
12.00
f1 (ppm)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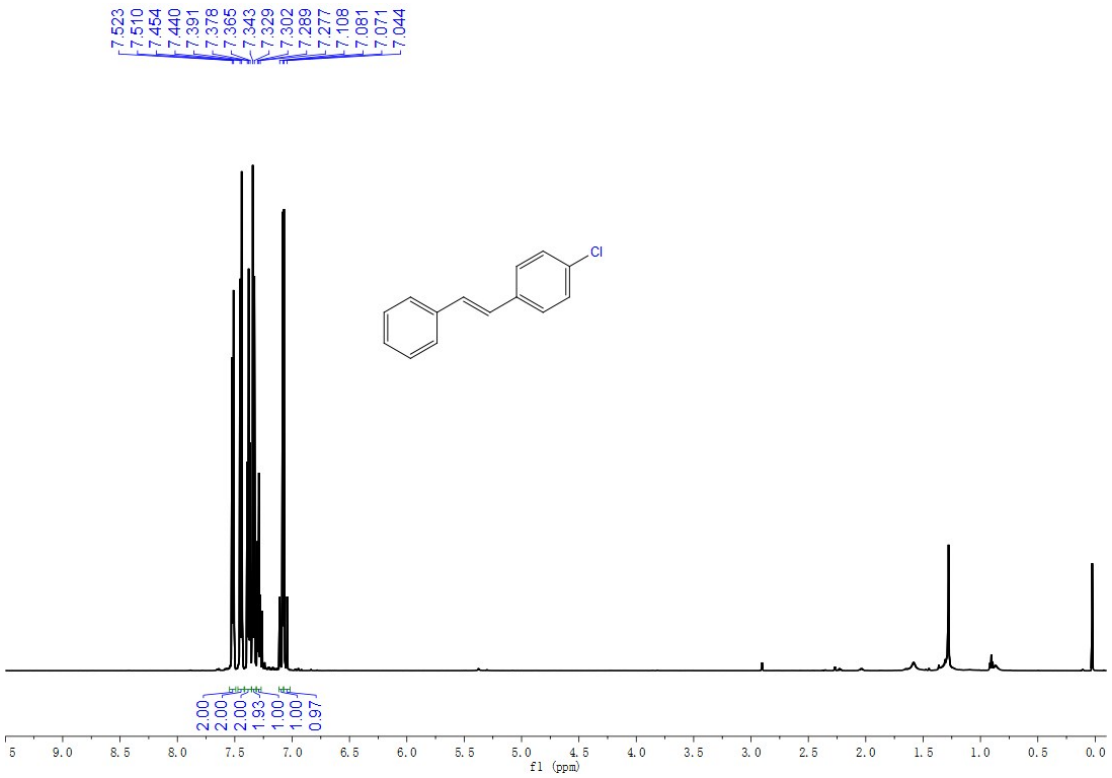
77.318
77.000
76.682
24.817
f1 (ppm)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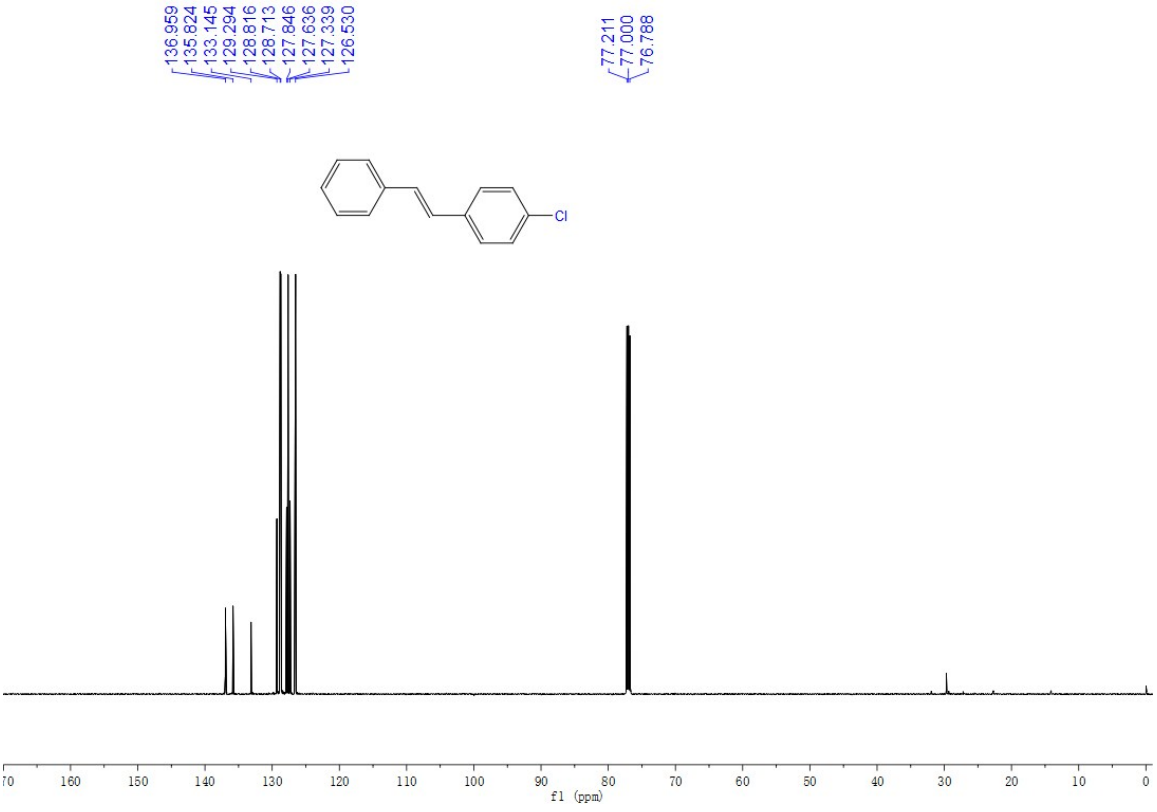
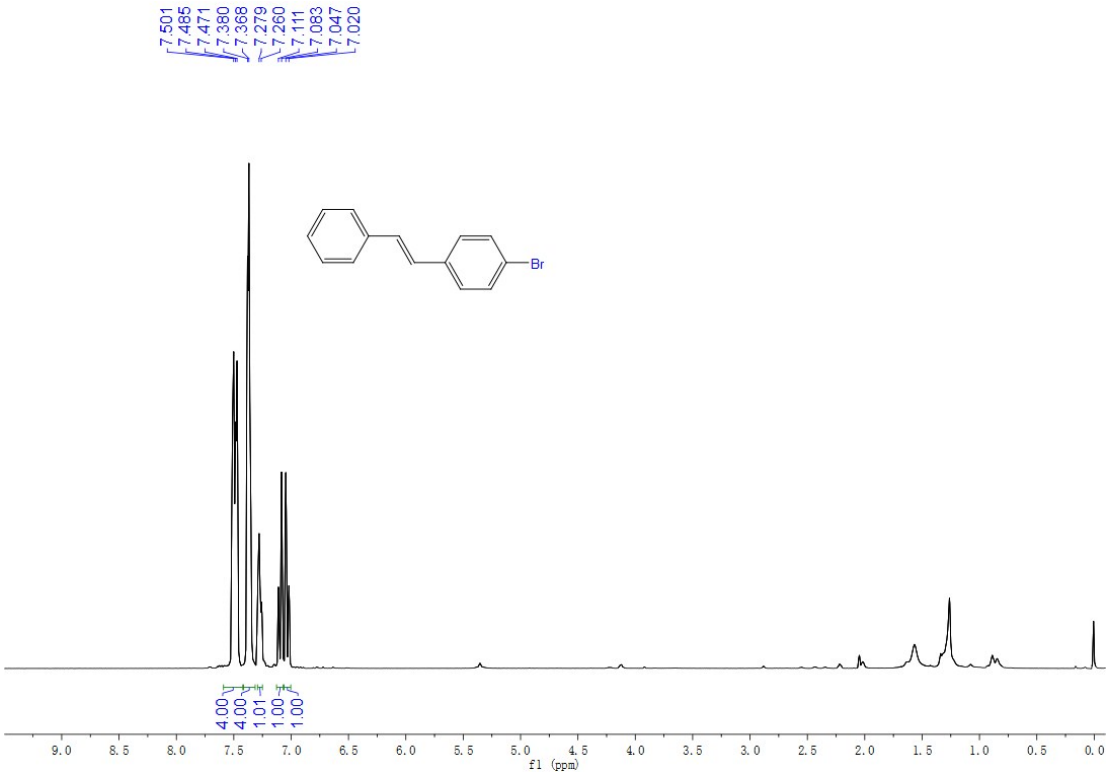
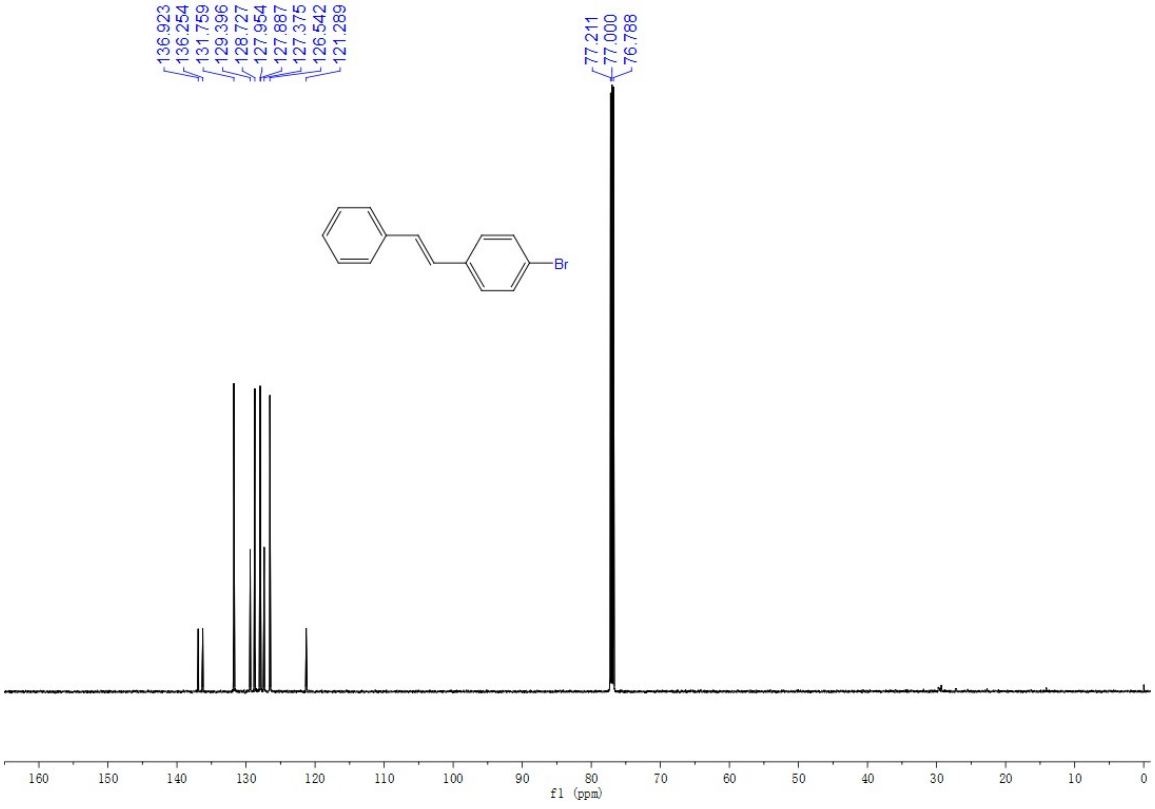
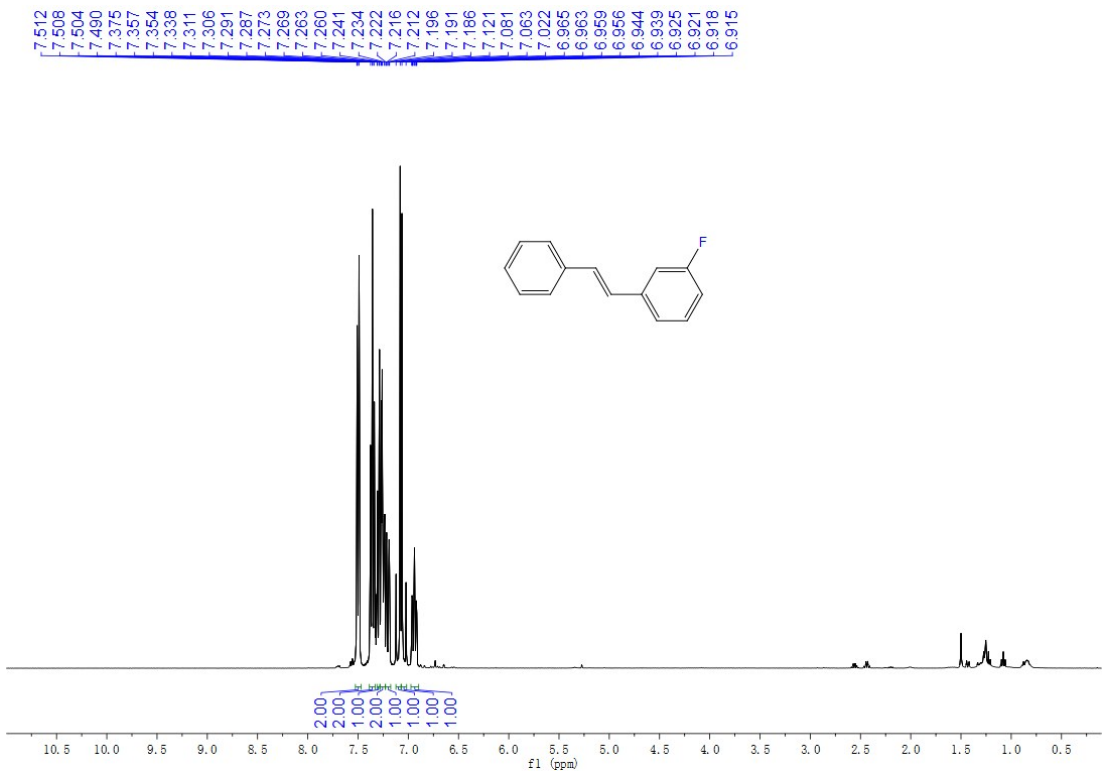
7.510
7.454
7.440
7.391
7.378
7.365
7.343
7.329
7.302
7.289
7.277
7.108
7.081
7.071
7.044
Cl
2.00
2.00
2.00
1.93
1.00
1.00
0.97
f1 (ppm)


136.959
135.824
133.145
129.294
128.816
128.713
127.846
127.636
127.339
126.530
77.211
77.000
76.788
Cl
f1 (ppm)


7.501
7.485
7.471
7.380
7.368
7.279
7.260
7.111
7.083
7.047
7.020
Br
4.00
4.00
1.01
1.00
1.00
f1 (ppm)


136.923
136.254
131.759
129.396
128.727
127.954
127.887
127.375
126.542
121.289
77.211
77.000
76.788
Br
f1 (ppm)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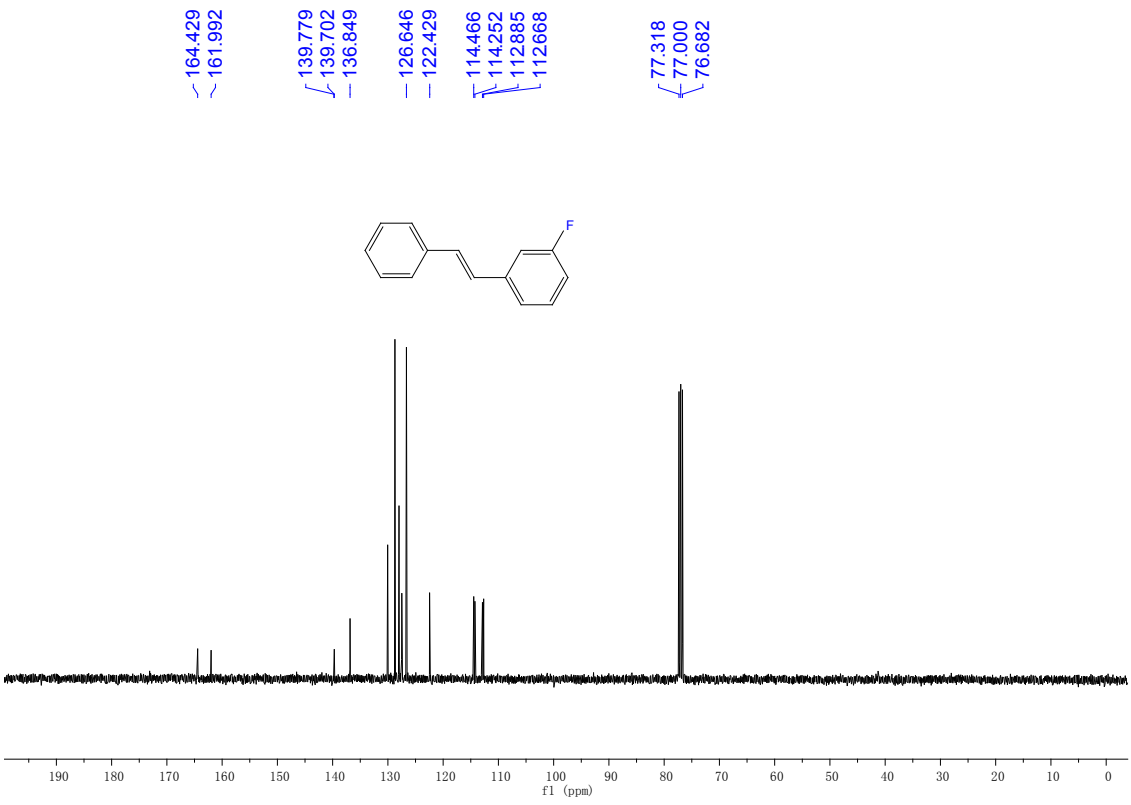
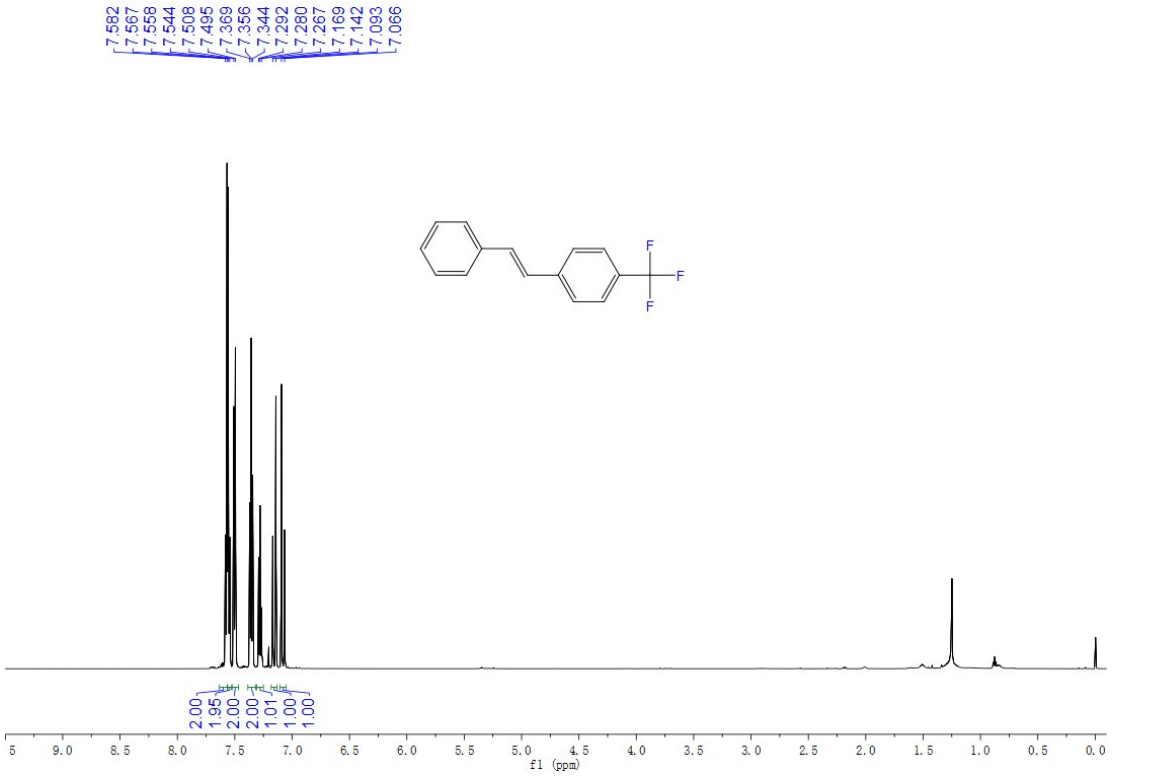
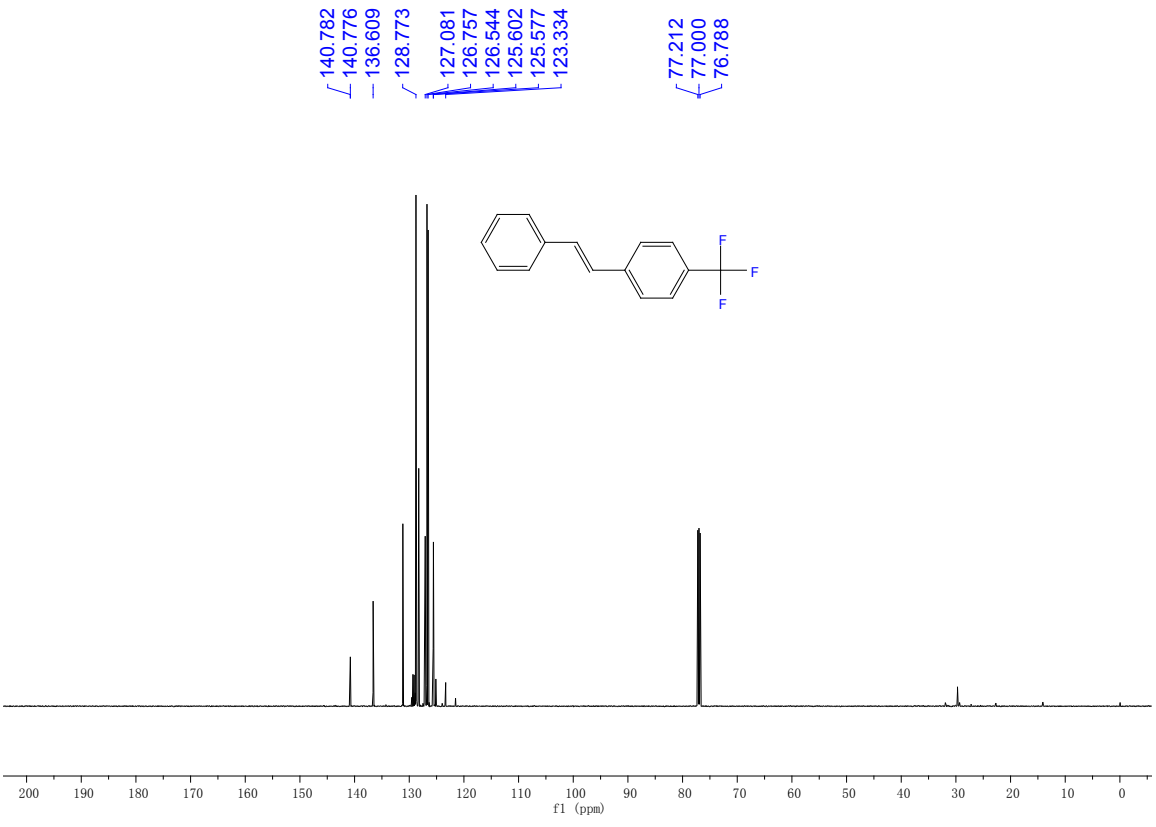
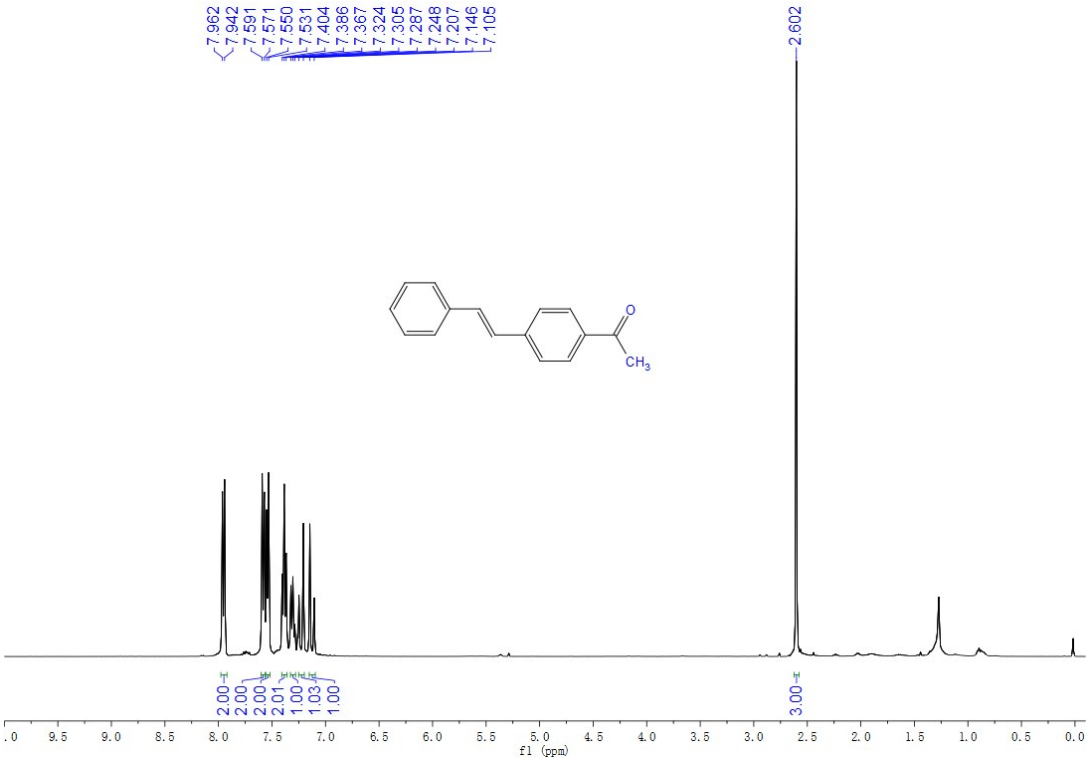
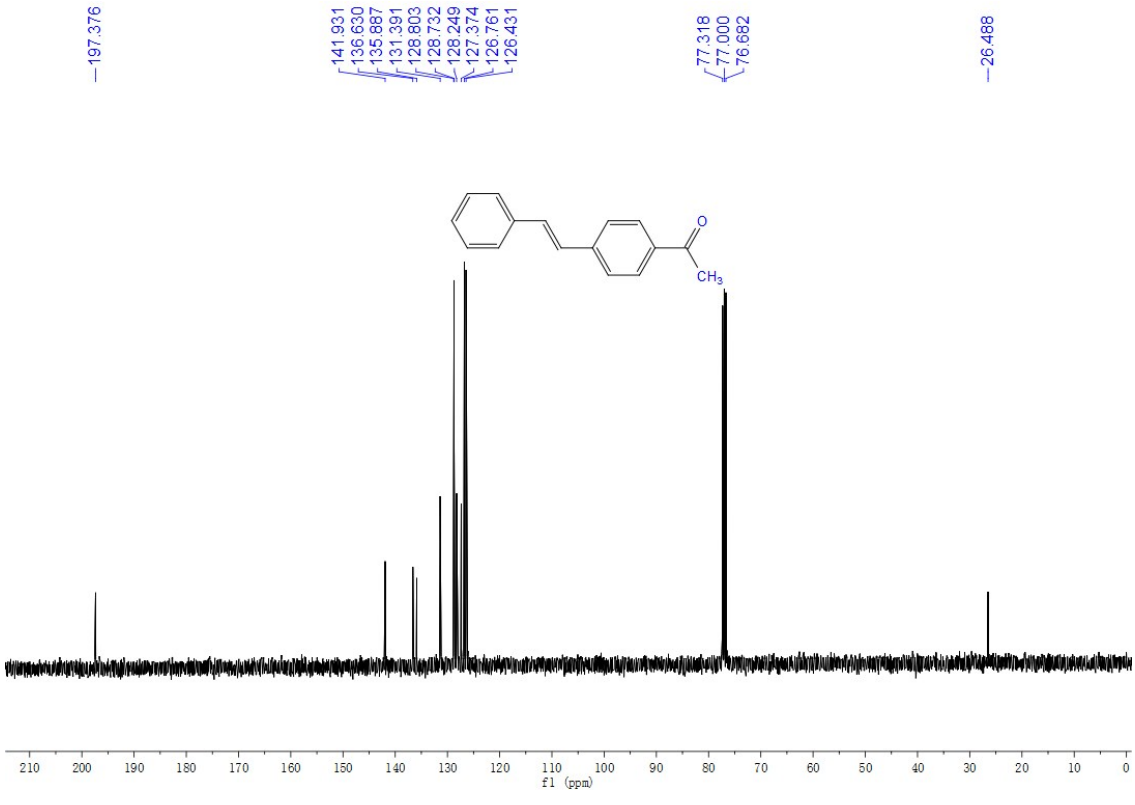
7.508
7.504
7.490
7.375
7.357
7.354
7.338
7.311
7.306
7.291
7.287
7.273
7.269
7.263
7.260
7.241
7.234
7.222
7.216
7.212
7.196
7.191
7.186
7.121
7.081
7.063
7.022
6.965
6.963
6.959
6.956
6.944
6.939
6.925
6.921
6.918
6.915
F
2.00
2.00
1.00
2.00
1.00
1.00
1.00
f1 (ppm)

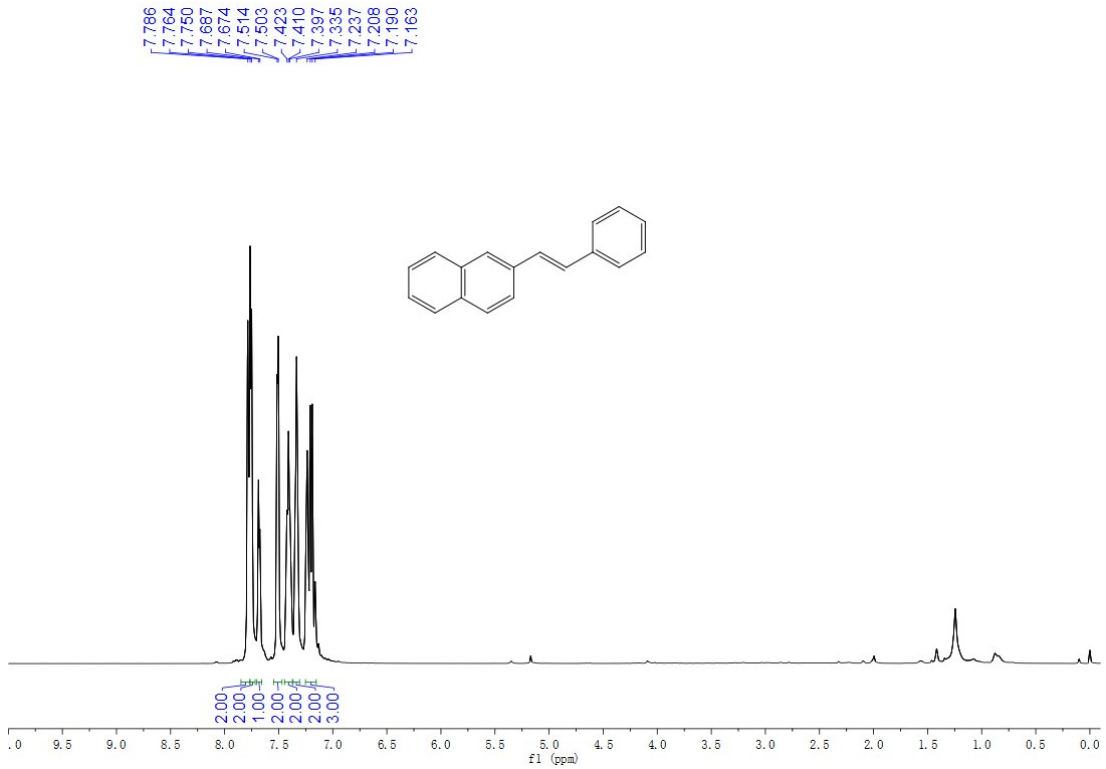

164.429
161.992
139.779
139.702
136.849
126.646
122.429
114.466
114.252
112.885
112.668
77.318
77.000
76.682
F
f1 (ppm)

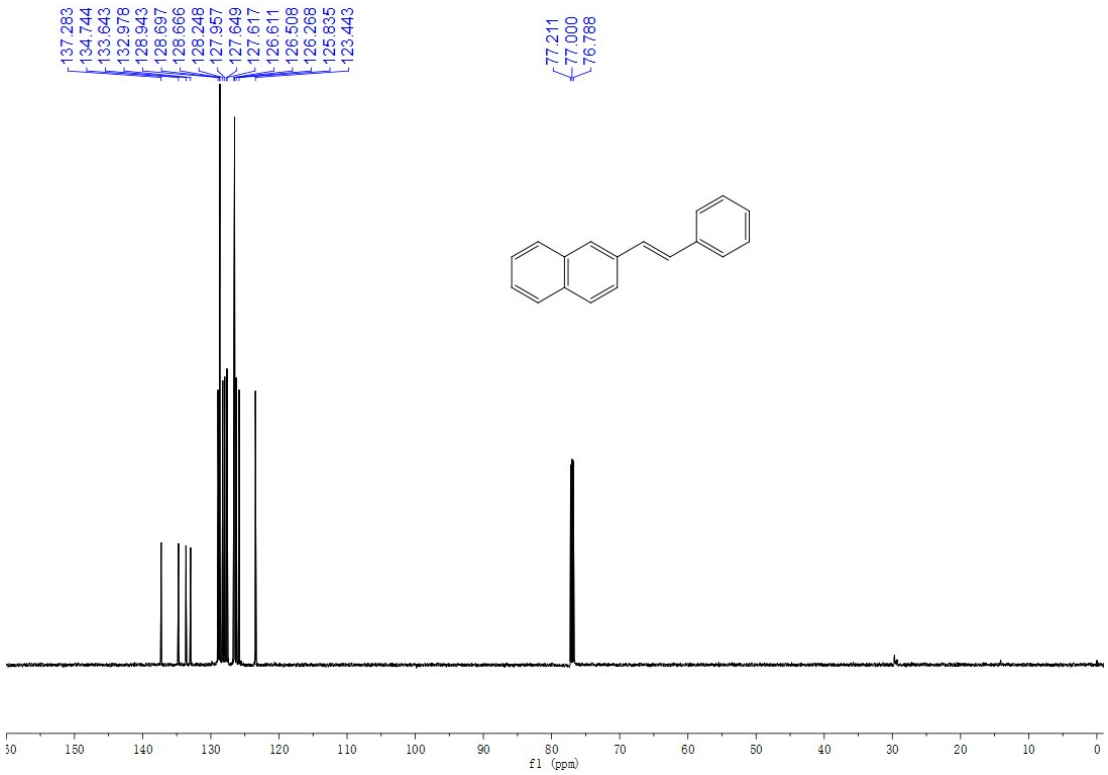

7.582
7.567
7.558
7.544
7.508
7.495
7.369
7.356
7.344
7.292
7.280
7.267
7.169
7.142
7.093
7.066
F
F
F
2.00
1.95
2.00
2.00
1.01
1.00
1.00
f1 (ppm)


140.782
140.776
136.609
128.773
127.081
126.757
126.544
125.602
125.577
123.334
77.212
77.000
76.788
F
F
F
f1 (ppm)


7.962
7.942
7.591
7.571
7.550
7.531
7.404
7.386
7.367
7.324
7.305
7.287
7.248
7.207
7.146
7.105
2.602
O
CH3
2.00
2.00
2.00
2.01
1.00
1.03
1.00
3.00
f1 (ppm)


197.376
141.931
136.630
135.887
131.391
128.803
128.732
128.249
127.374
126.761
126.431
77.318
77.000
76.682
26.488
O
CH3
f1 (ppm)


7.786
7.764
7.750
7.687
7.674
7.514
7.503
7.423
7.410
7.397
7.335
7.237
7.208
7.190
7.163
2.00
2.00
1.00
2.00
2.00
2.00
3.00
f1 (ppm)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134.744
133.643
132.978
128.943
128.697
128.666
128.248
127.957
127.649
127.617
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126.508
126.268
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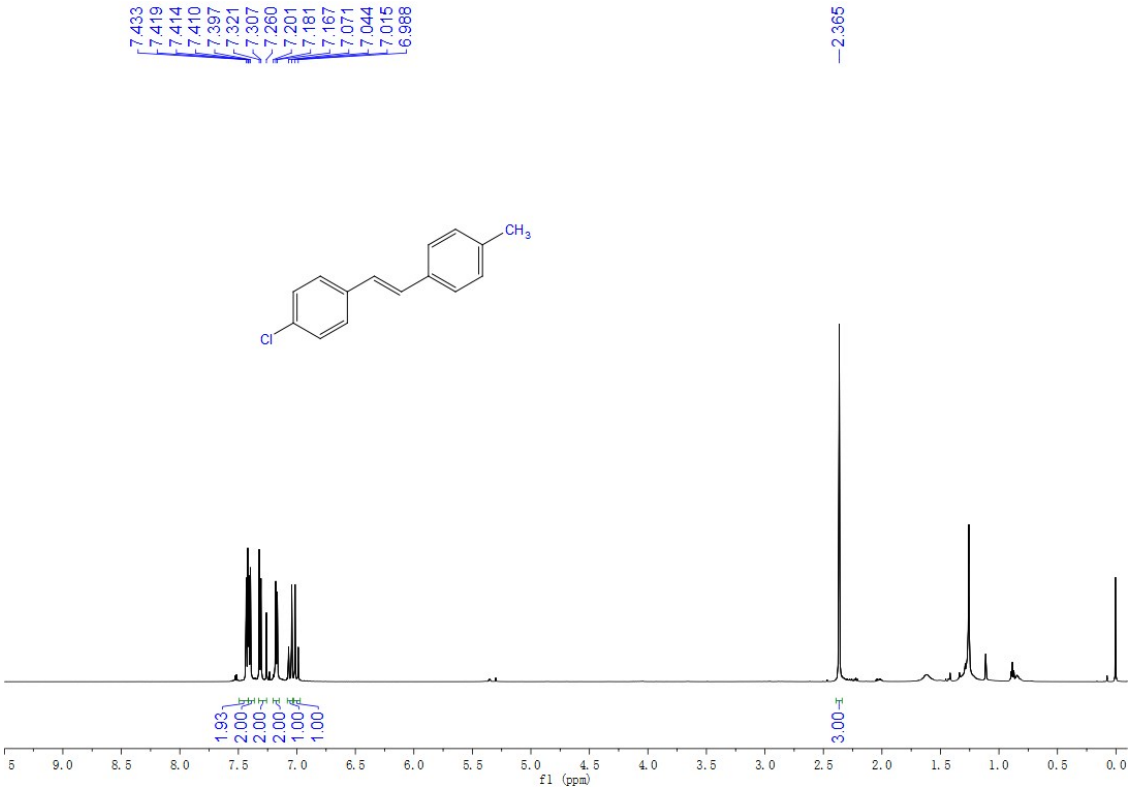
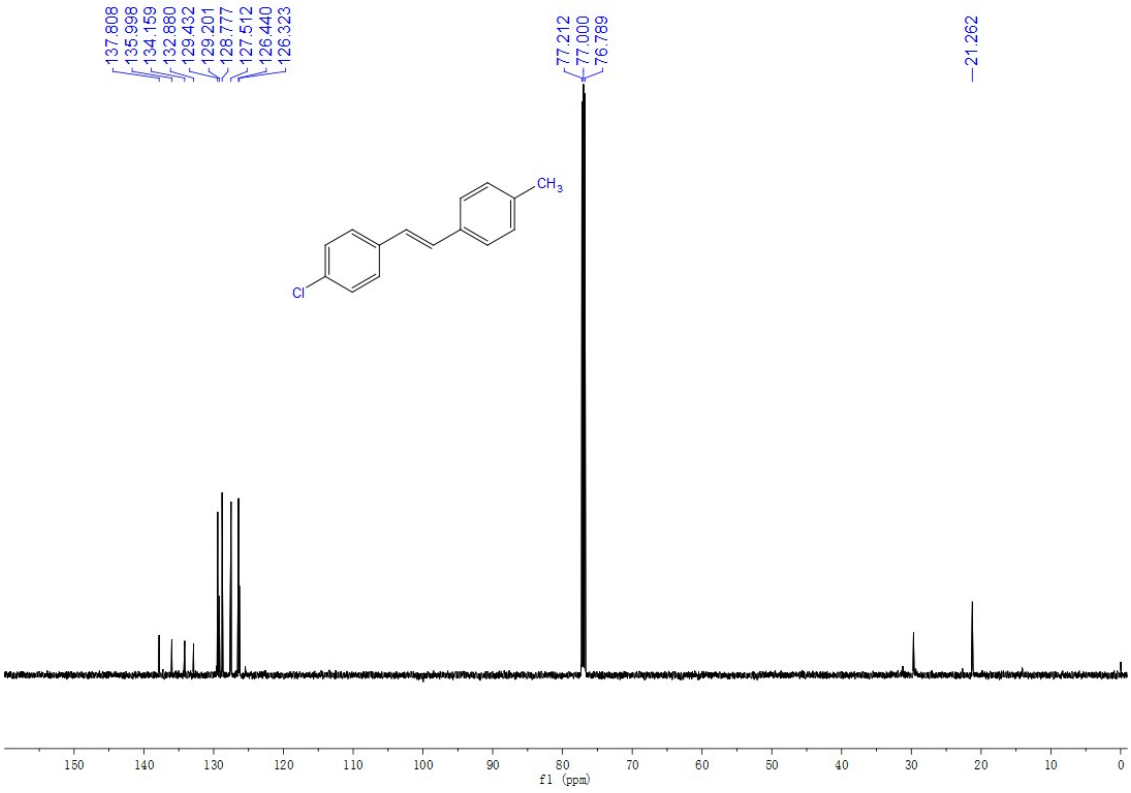
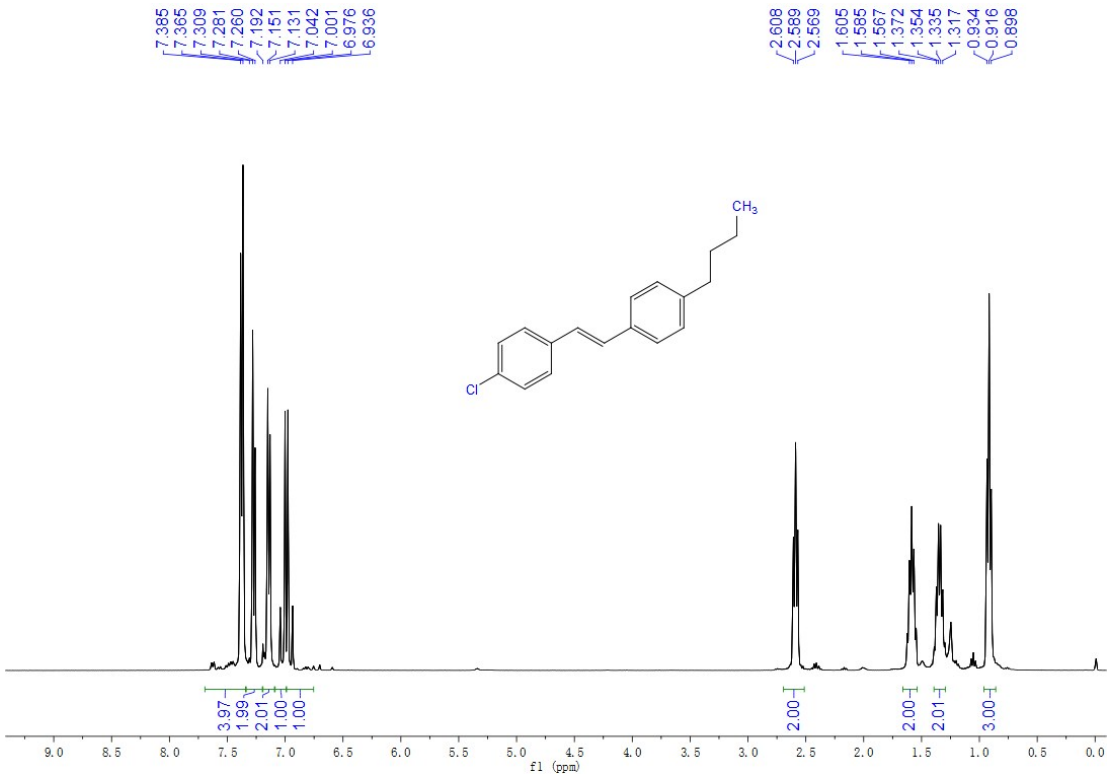
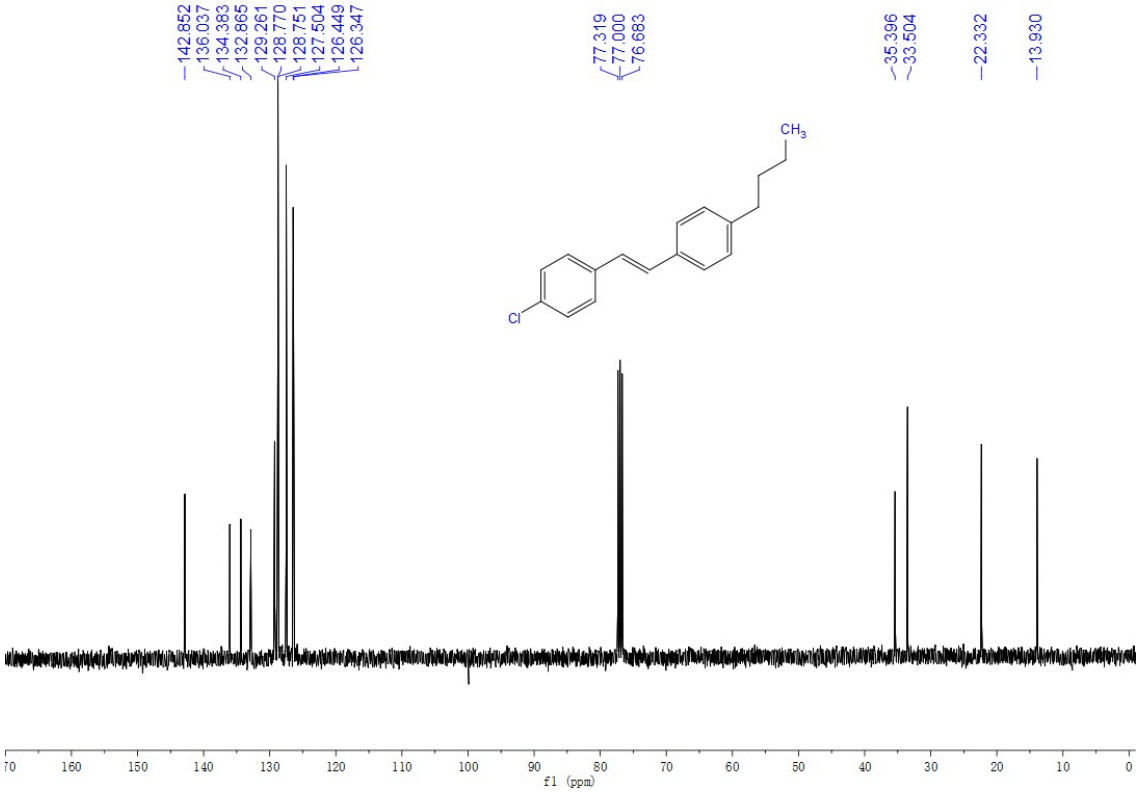
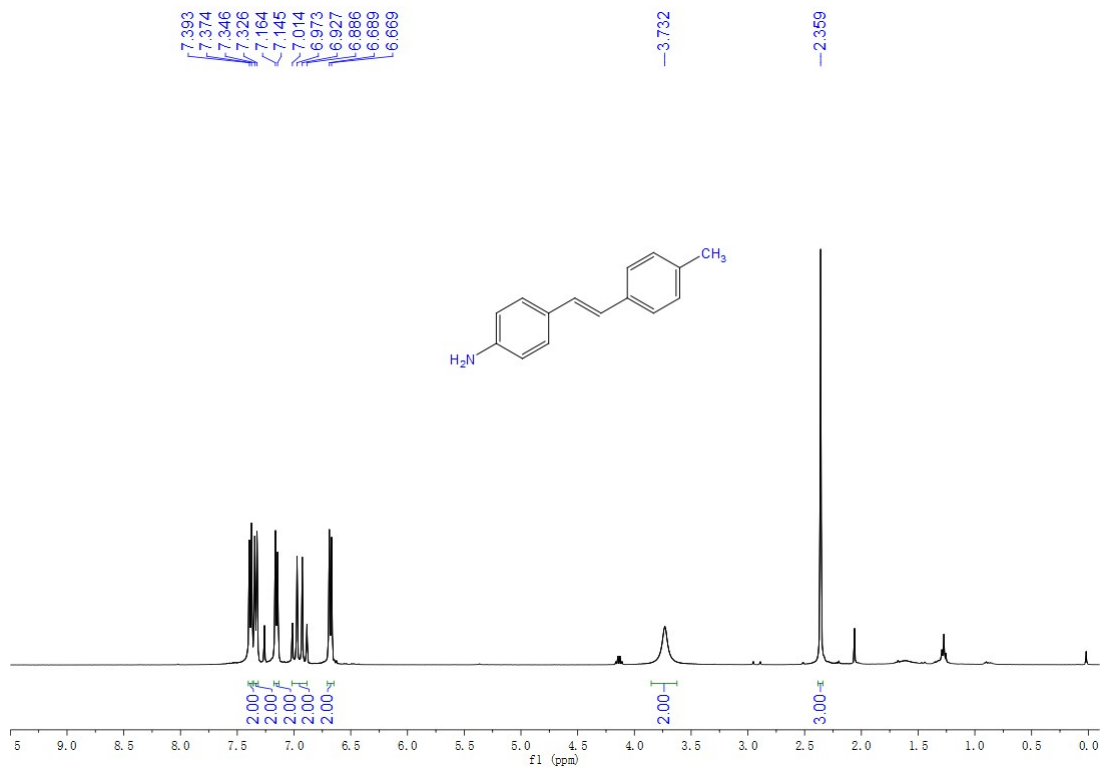
123.443
77.211
77.000
76.788
f1 (ppm)

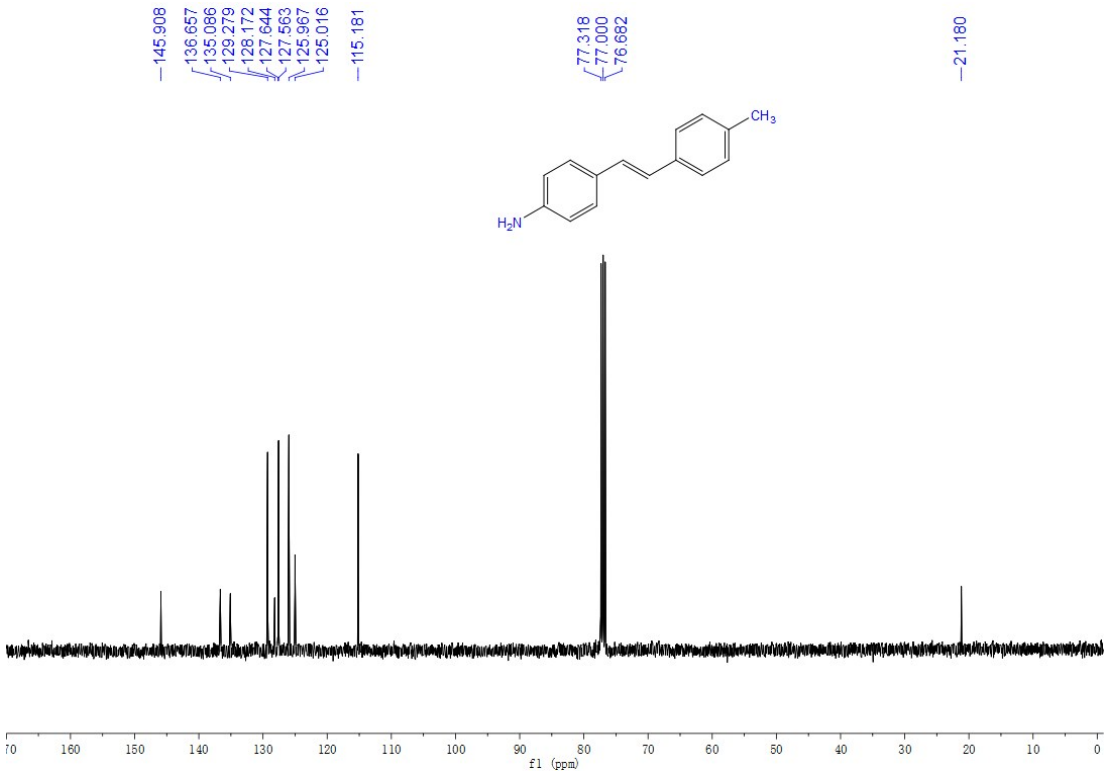

7.433
7.419
7.414
7.410
7.397
7.321
7.307
7.260
7.201
7.181
7.167
7.071
7.044
7.015
6.988
2.365
CH3
Cl
1.93
2.00
2.00
2.00
1.00
1.00
3.00
f1 (ppm)

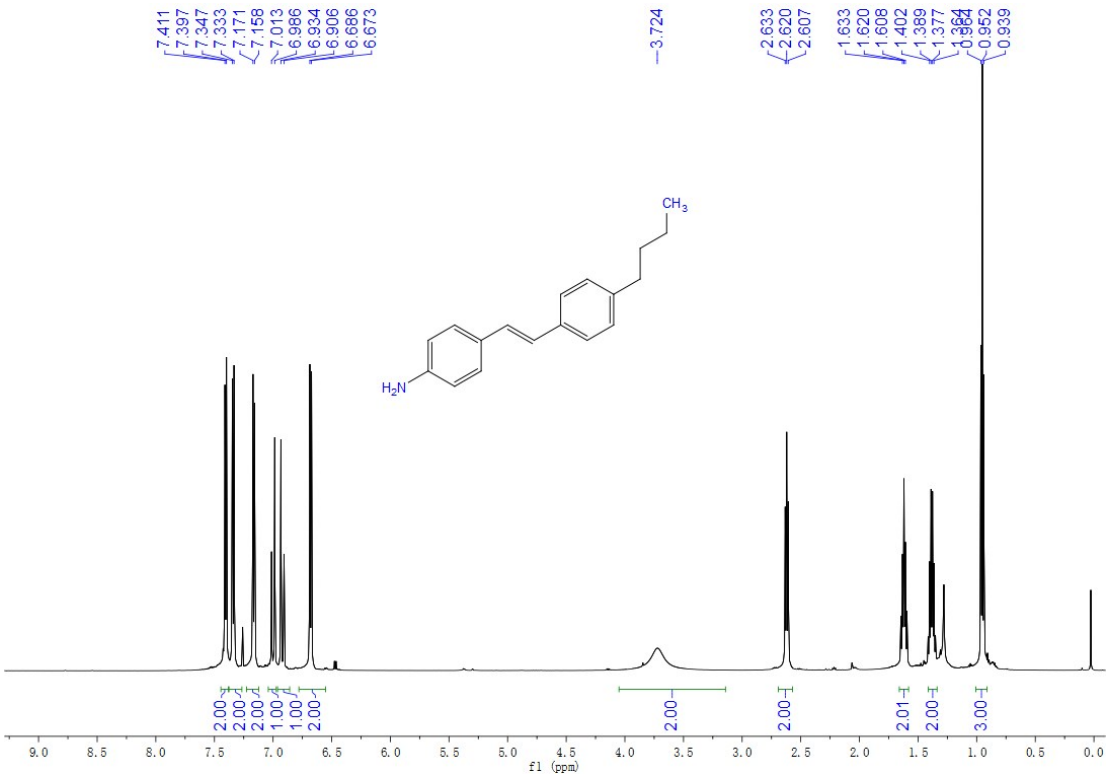

137.808
135.998
134.159
132.880
129.432
129.201
128.777
127.512
126.440
126.323
77.212
77.000
76.789
21.262
CH3
Cl
f1 (ppm)

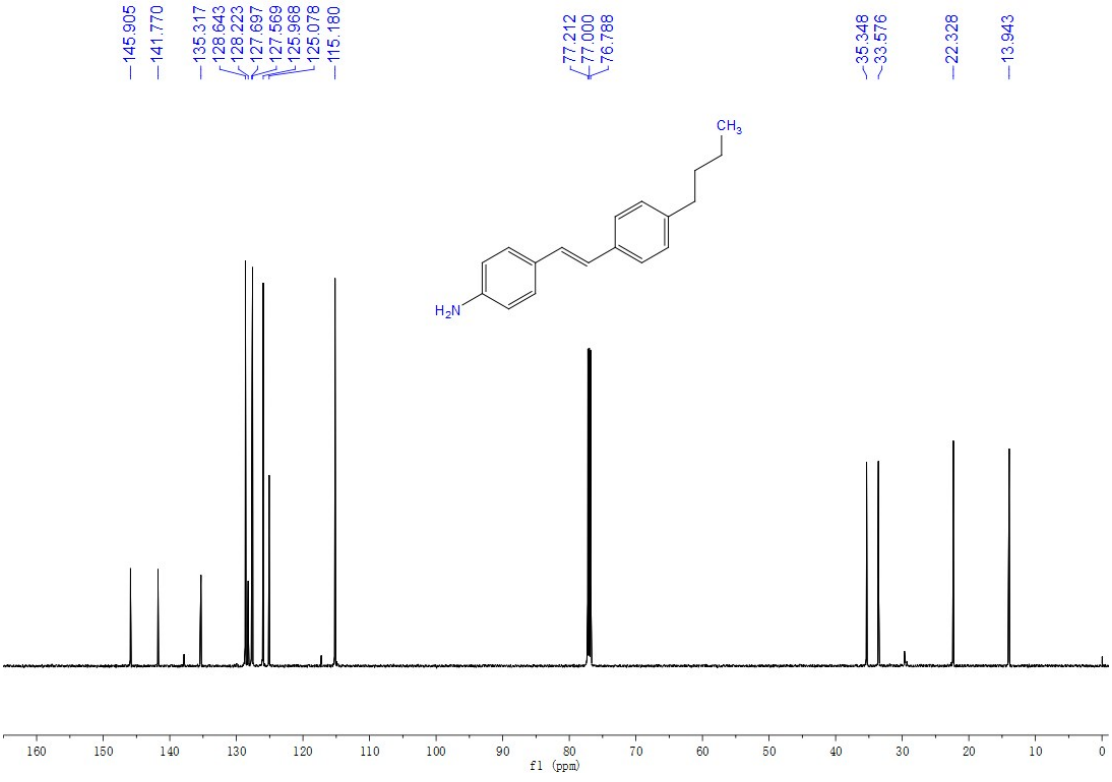

7.385
7.365
7.309
7.281
7.260
7.192
7.151
7.131
7.042
7.001
6.976
6.936
2.608
2.589
2.569
1.605
1.585
1.567
1.372
1.354
1.335
1.317
0.934
0.916
0.898
CH3
Cl
3.97
1.99
2.01
1.00
1.00
2.00
2.00
2.01
3.00
f1 (ppm)

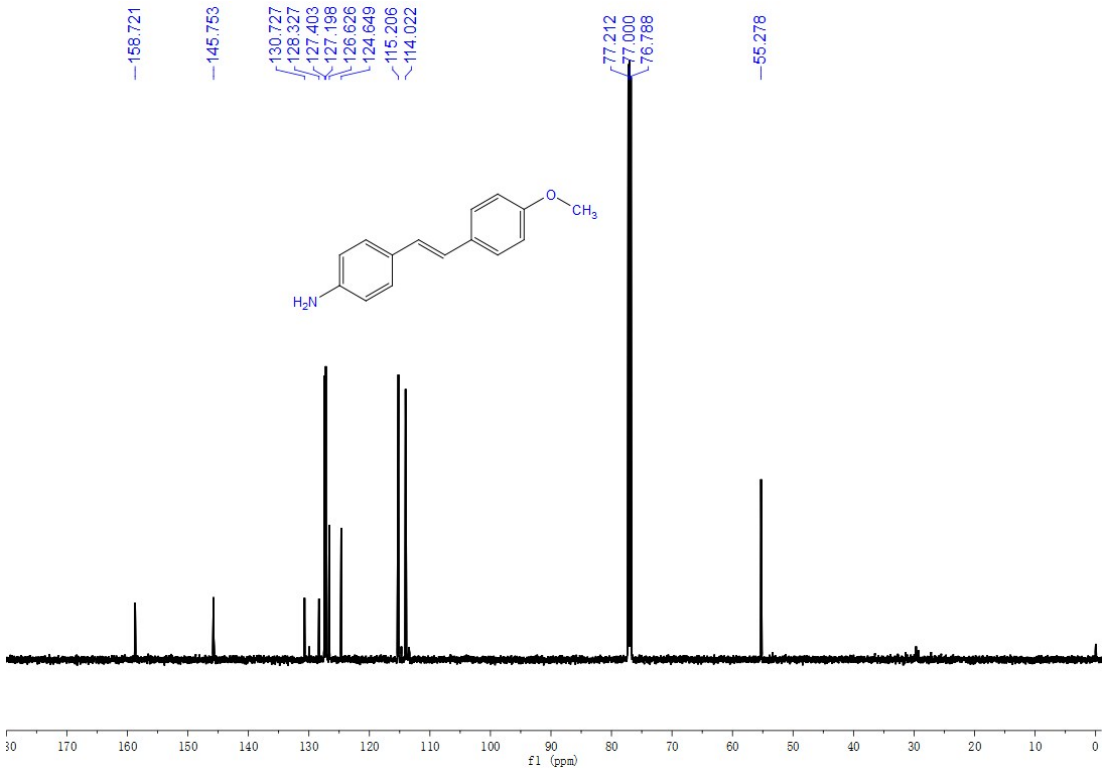

142.852
136.037
134.383
132.865
129.261
128.770
128.751
127.504
126.449
126.347
77.319
77.000
76.683
35.396
33.504
22.332
13.930
CH3
Cl
f1 (ppm)

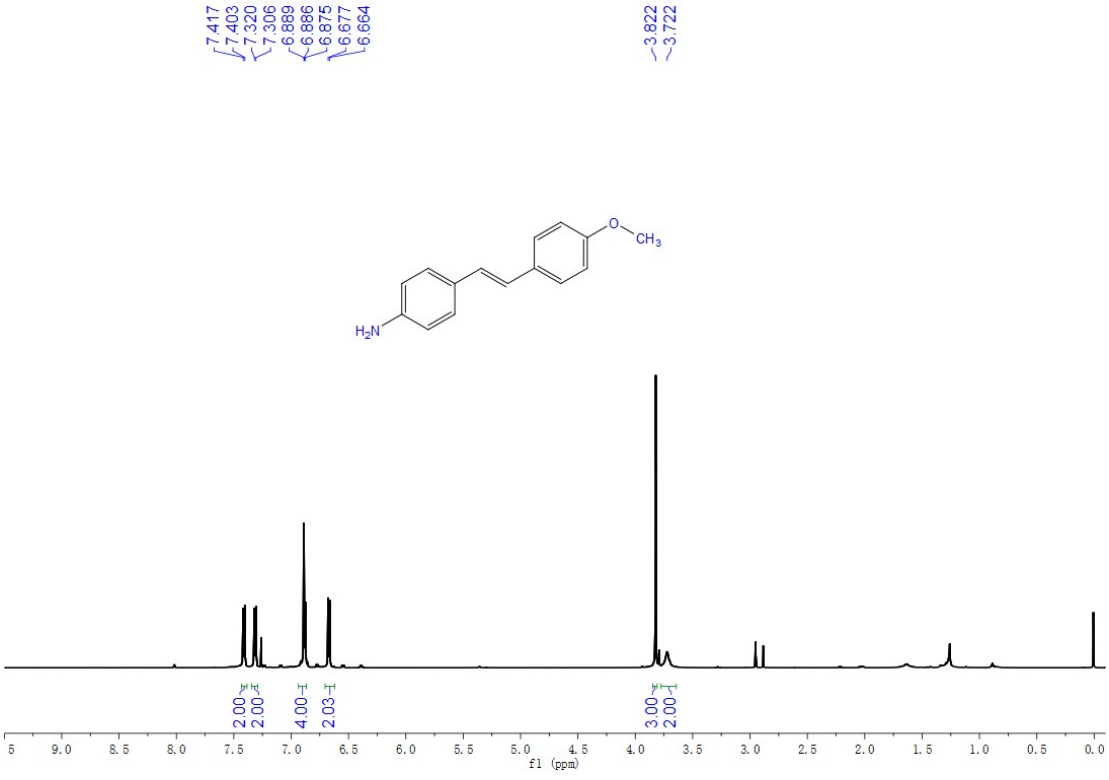

7.393
7.374
7.346
7.326
7.164
7.145
7.014
6.973
6.927
6.886
6.689
6.669
3.732
2.359
CH3
H2N
2.00
2.00
2.00
2.00
2.00
2.00
3.00
f1 (ppm)

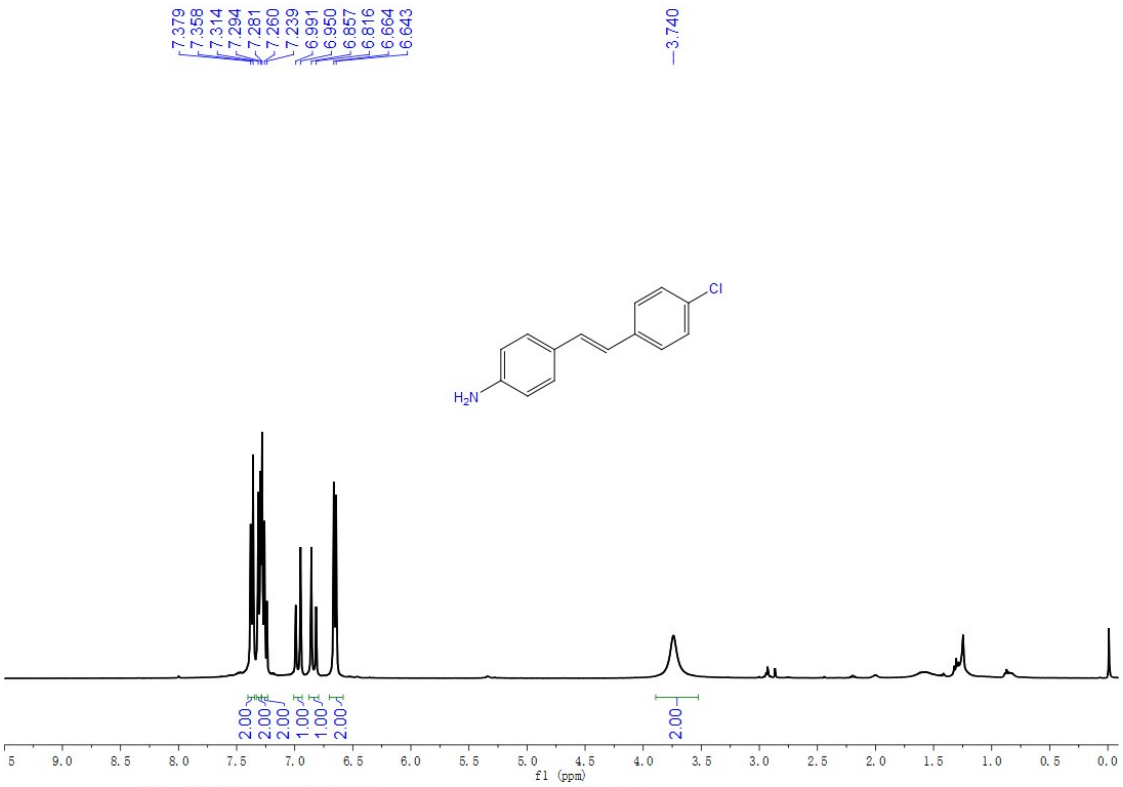

145.908
136.657
135.086
129.279
128.172
127.644
127.563
125.967
125.016
115.181
77.318
77.000
76.682
21.180
CH3
H2N
f1 (ppm)

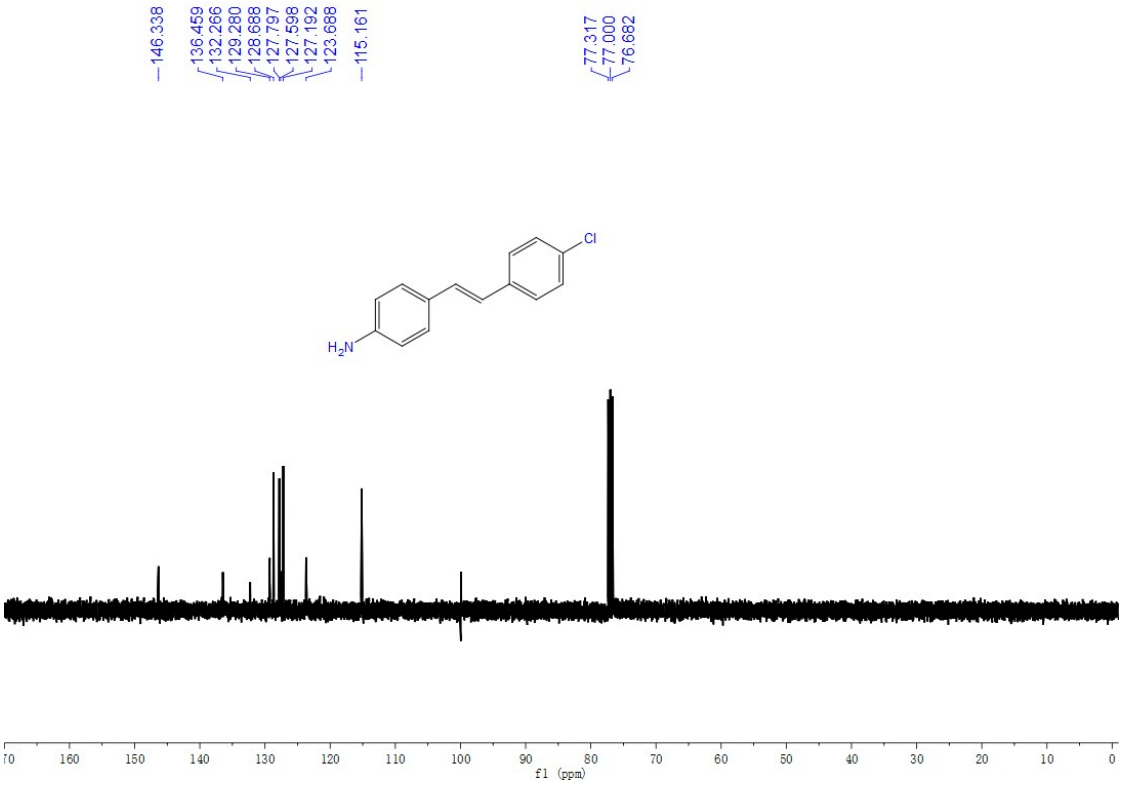

7.411
7.397
7.347
7.333
7.171
7.158
7.013
6.986
6.934
6.906
6.686
6.673
3.724
2.633
2.620
2.607
1.633
1.620
1.608
1.402
1.389
1.377
0.952
0.939
CH3
H2N
2.00
2.00
2.00
1.00
1.00
2.00
2.00
2.00
2.01
2.00
3.00
f1 (ppm)

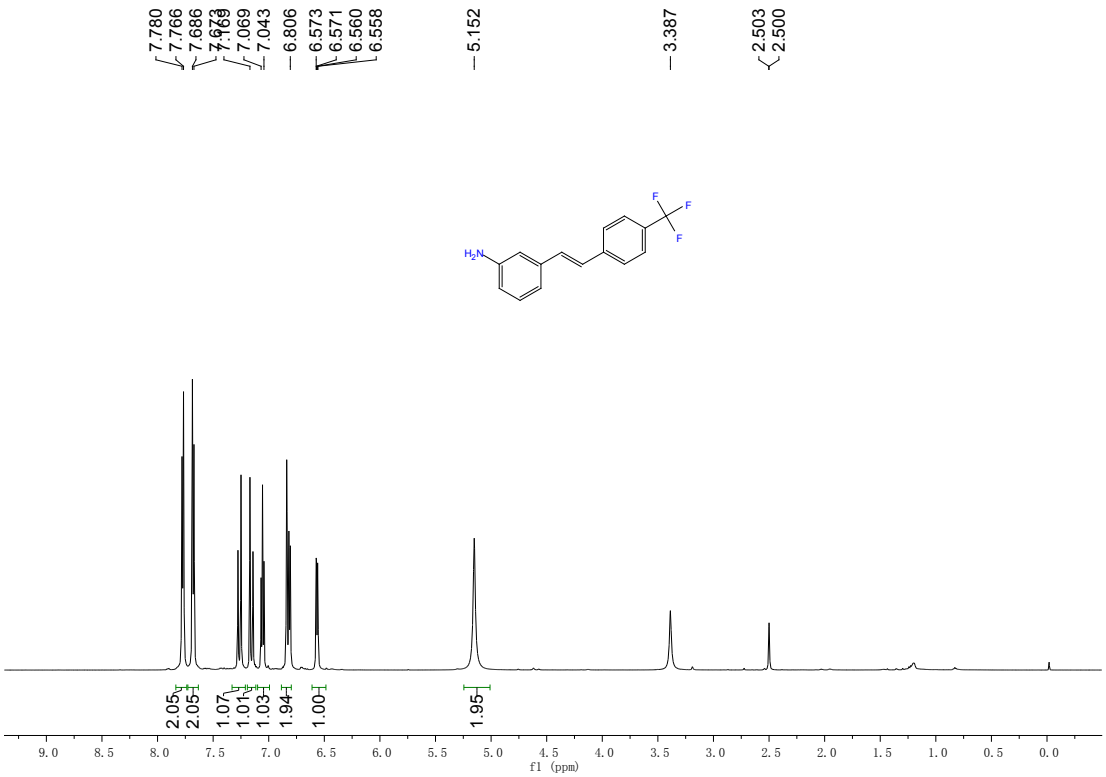

145.905
141.770
135.317
128.643
128.223
127.697
127.569
125.968
125.078
115.180
77.212
77.000
76.788
35.348
33.576
22.328
13.943
CH3
H2N
f1 (ppm)

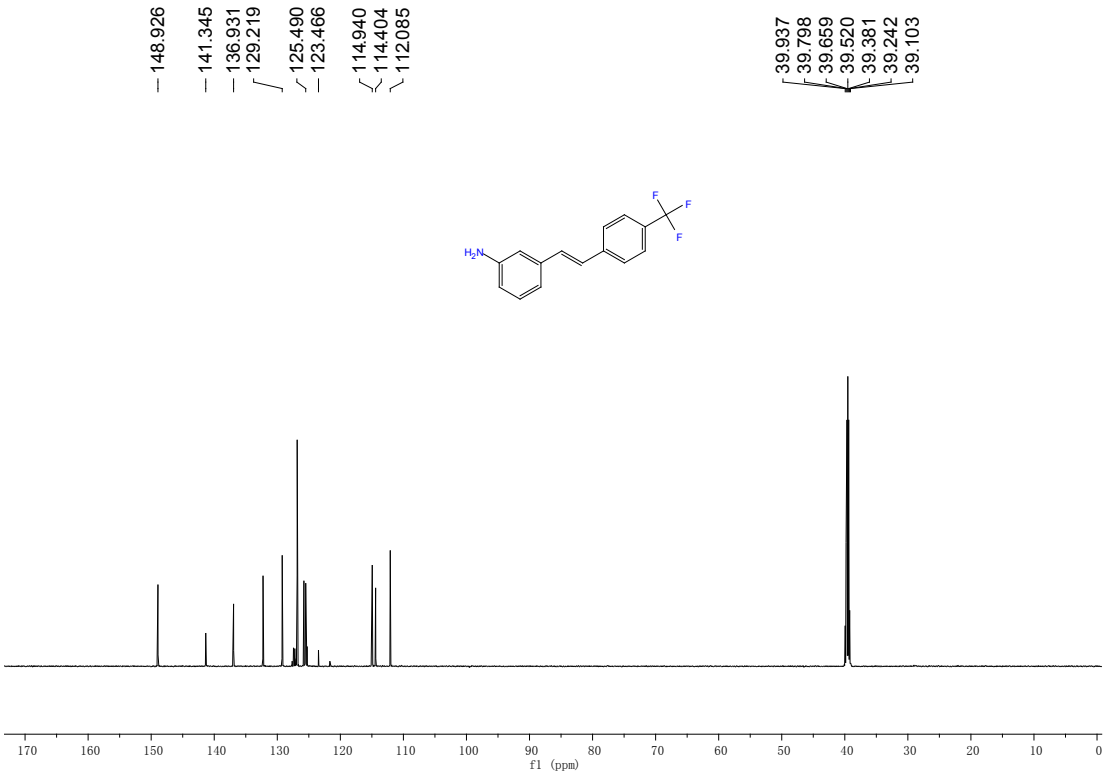

158.721
145.753
130.727
128.327
127.403
127.198
126.626
124.649
115.206
114.022
77.212
77.000
76.788
55.278
O
CH3
H2N
f1 (ppm)


7.417
7.403
7.320
7.306
6.889
6.886
6.875
6.677
6.664
3.822
3.722
O
CH3
H2N
2.00
2.00
4.00
2.03
3.00
2.00
f1 (ppm)


7.379
7.358
7.314
7.294
7.281
7.260
7.239
6.991
6.950
6.857
6.816
6.664
6.643
3.740
Cl
H2N
2.00
2.00
2.00
1.00
1.00
2.00
2.00
f1 (ppm)


146.338
136.459
132.266
129.280
128.688
127.797
127.598
127.192
123.688
115.161
77.317
77.000
76.682
Cl
H2N
f1 (ppm)


7.780
7.766
7.686
7.069
7.043
6.806
6.573
6.571
6.560
6.558
5.152
3.387
2.503
2.500
F
F
F
H2N
2.05
2.05
1.07
1.01
1.03
1.94
1.00
1.95
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


148.926
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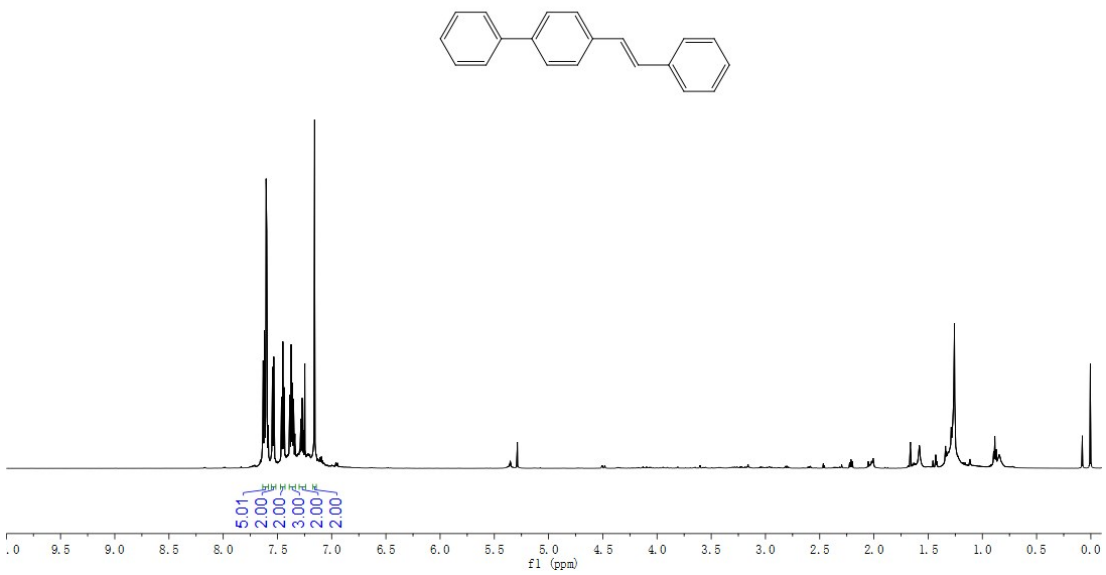
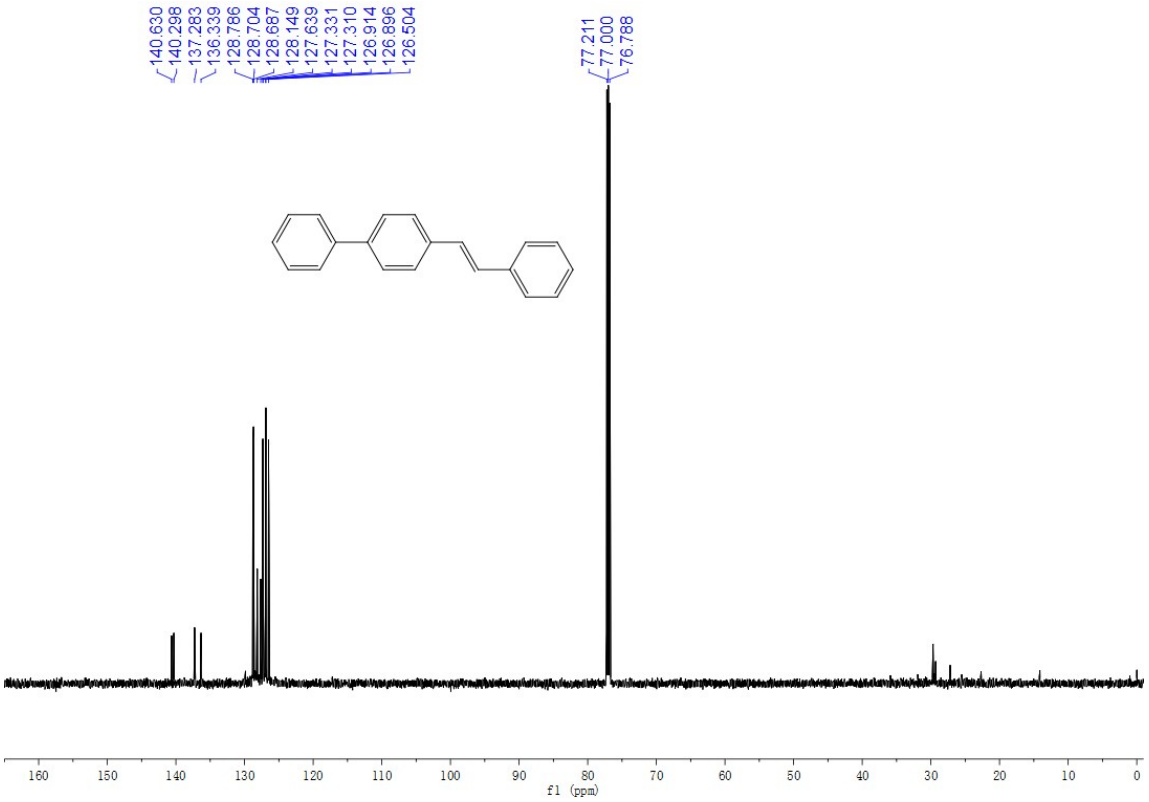
136.931
129.219
125.490
123.466
114.940
114.404
112.085
39.937
39.798
39.659
39.520
39.381
39.242
39.103
F
F
F
H2N
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.634
7.631
7.628
7.619
7.619
7.615
7.608
7.604
7.599
7.595
7.589
7.585
7.548
7.546
7.534
7.463
7.460
7.450
7.440
7.437
7.386
7.383
7.374
7.366
7.364
7.361
7.352
7.339
7.286
7.285
7.283
7.272
7.262
7.260
7.258
7.248
7.157


5.01
2.00
2.00
3.00
2.00
2.00
f1 (ppm)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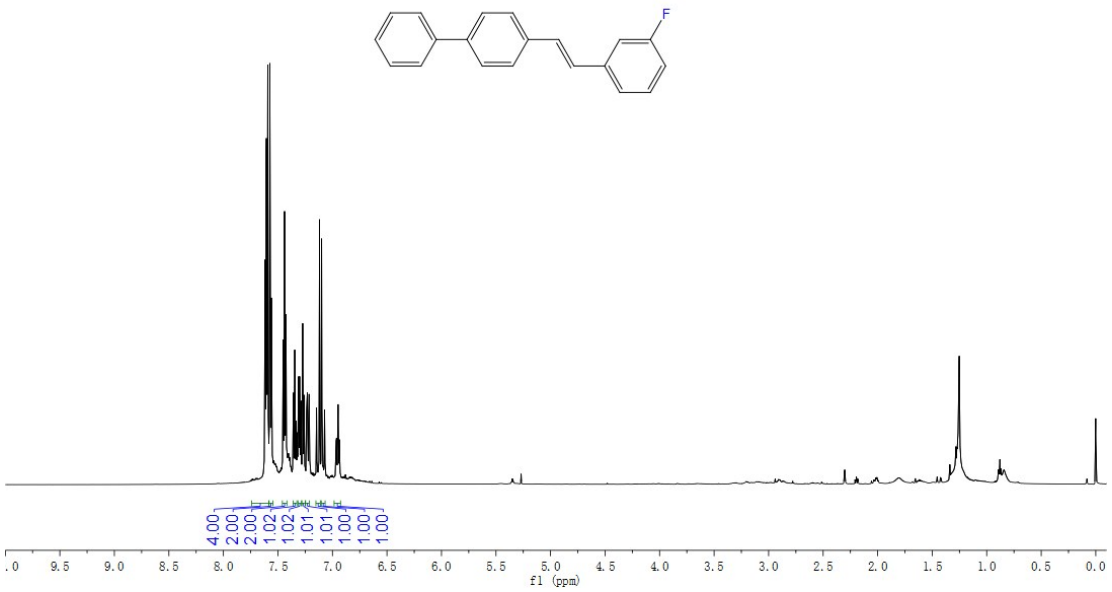
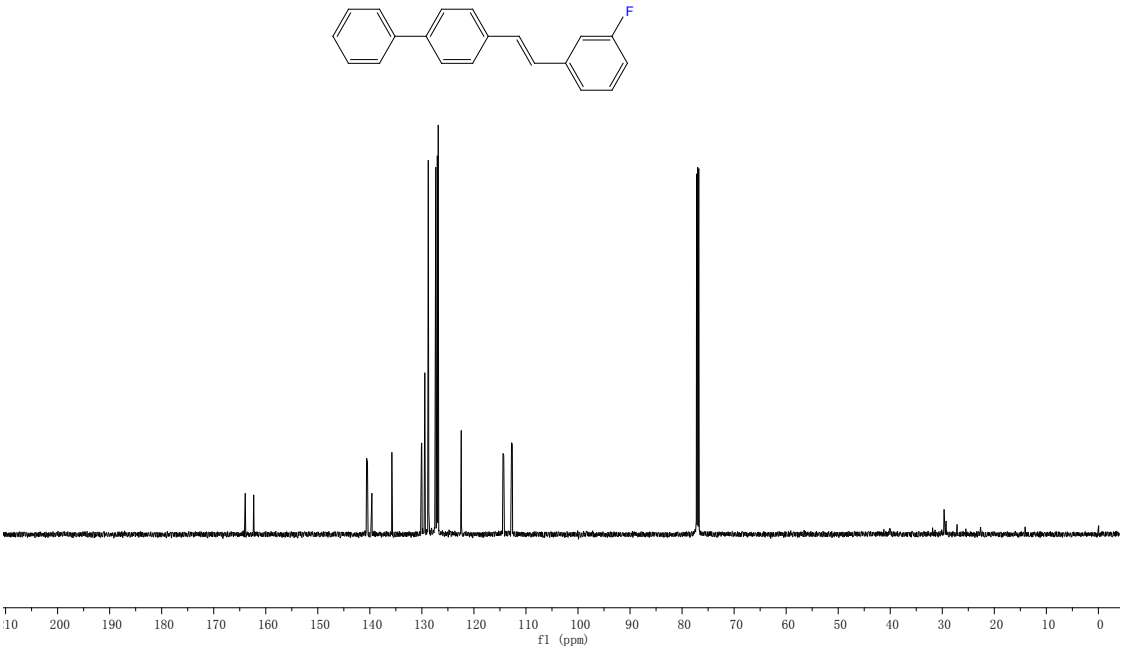
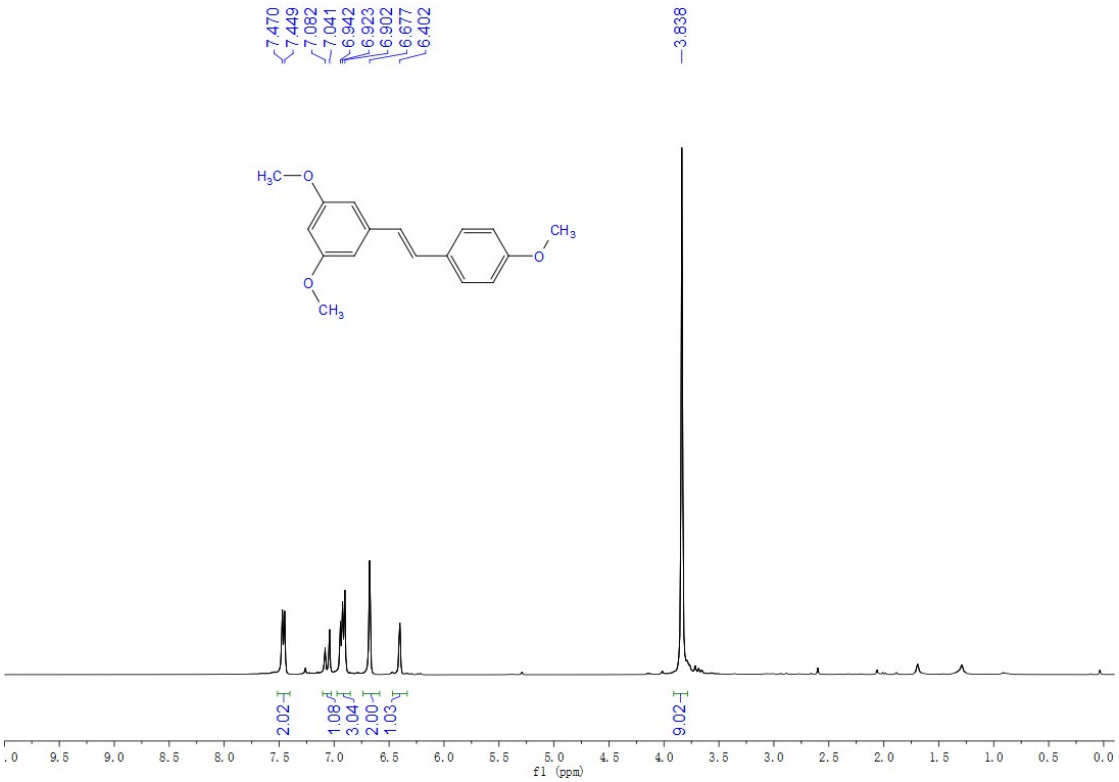
140.298
137.283
136.339
128.786
128.704
128.687
128.149
127.639
127.331
127.310
126.914
126.896
126.504
77.211
77.000
76.788
f1 (ppm)

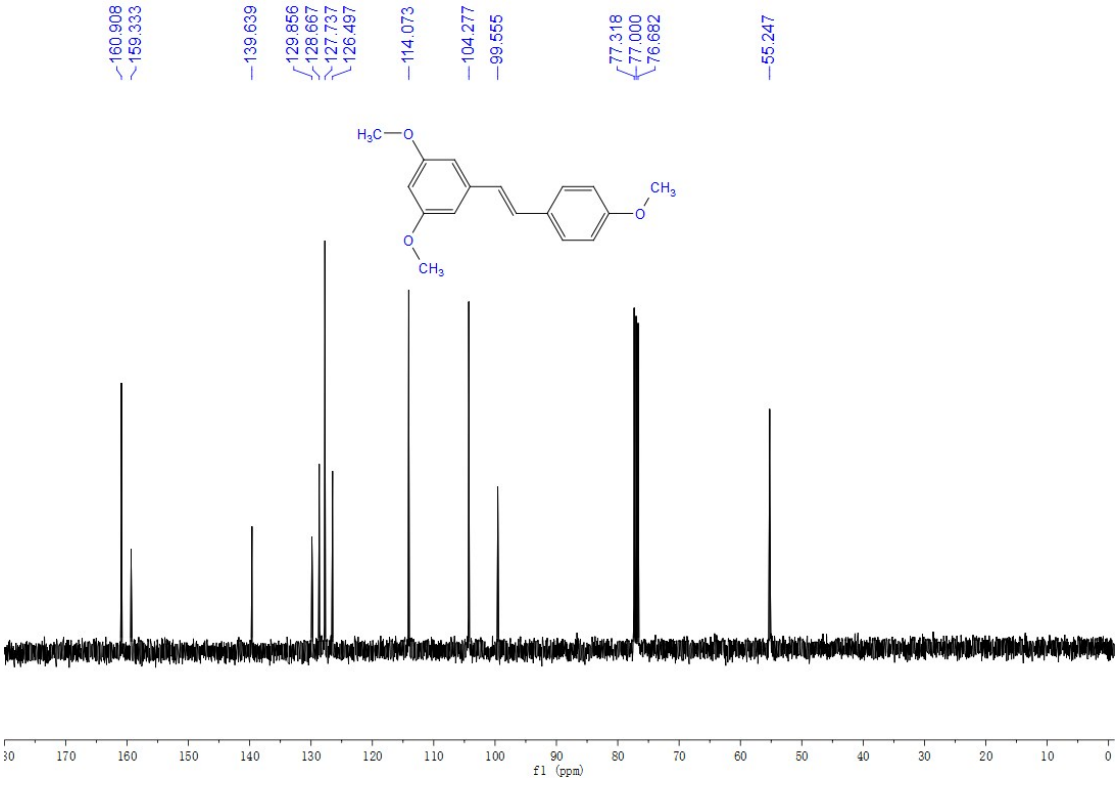

7.617
7.607
7.606
7.594
7.574
7.560
7.452
7.439
7.426
7.358
7.346
7.334
7.324
7.314
7.311
7.301
7.298
7.288
7.273
7.260
7.237
7.234
7.231
7.214
7.146
7.118
7.099
7.072
6.965
6.962
6.952
6.949
6.939
6.937
6.935

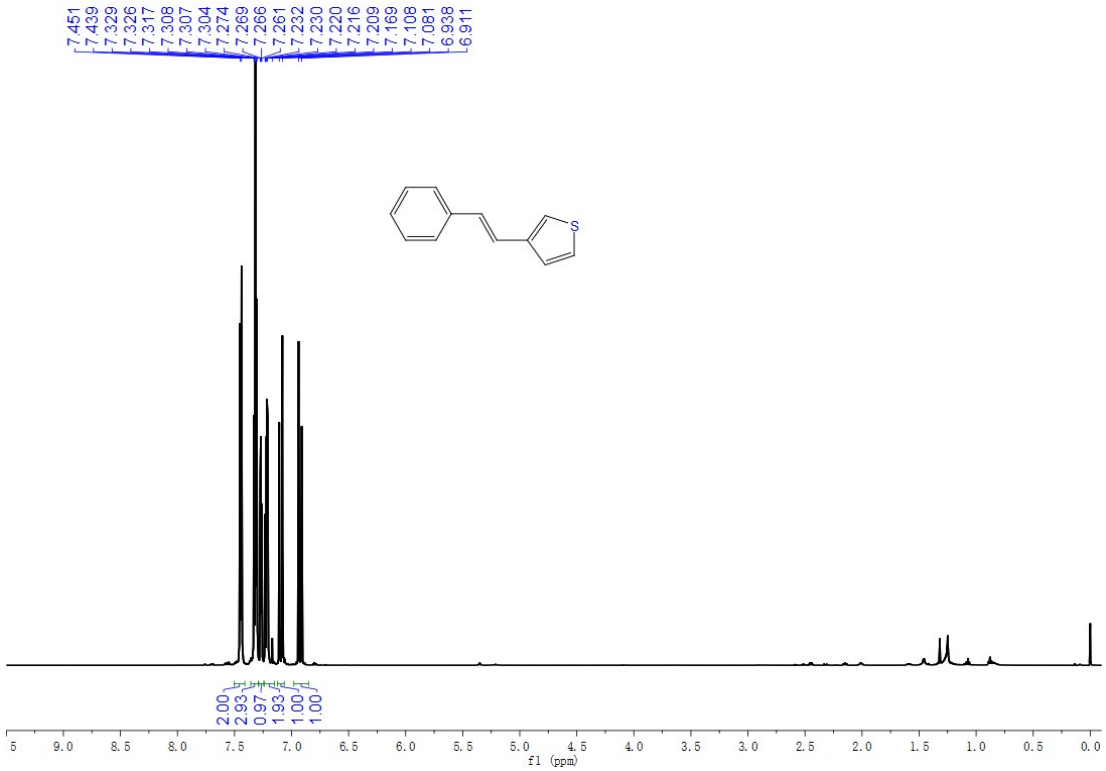

F
4.00
2.00
2.00
1.02
1.02
1.01
1.01
1.00
1.00
1.00
f1 (ppm)

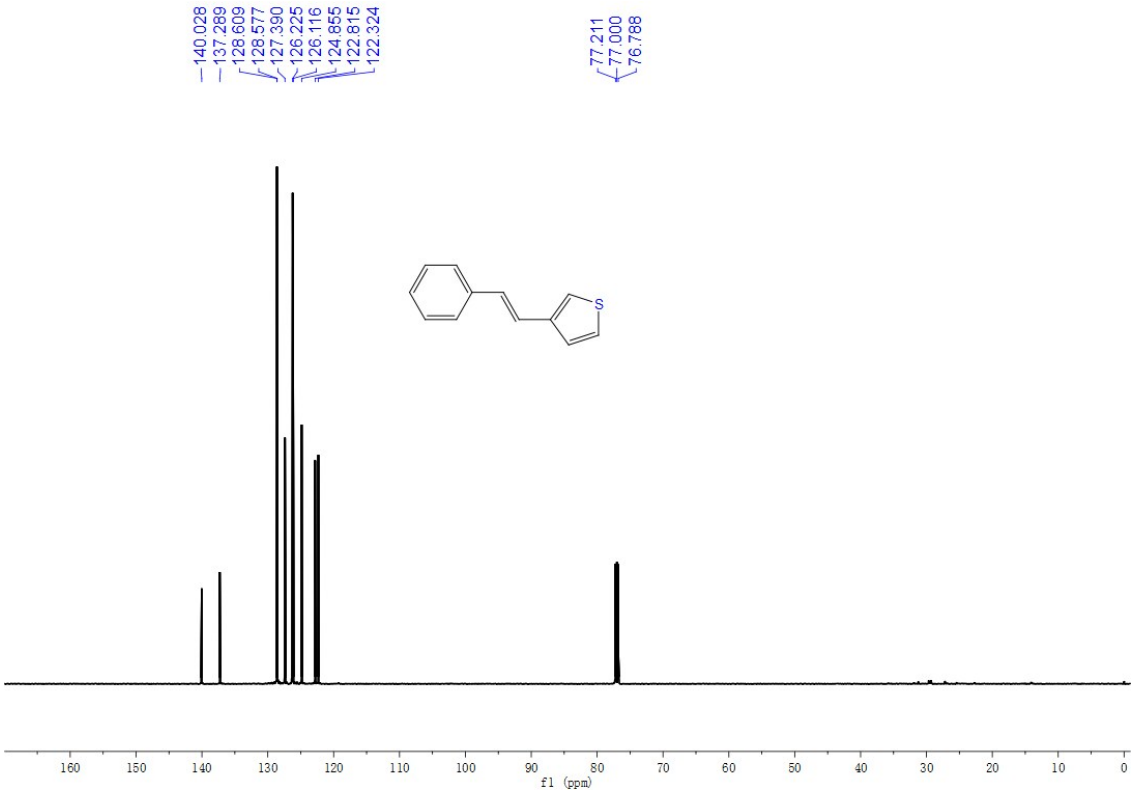

163.941
162.316
140.456
139.654
139.603
135.769
126.859
122.419
114.413
114.271
112.771
112.626
77.212
77.000
76.788

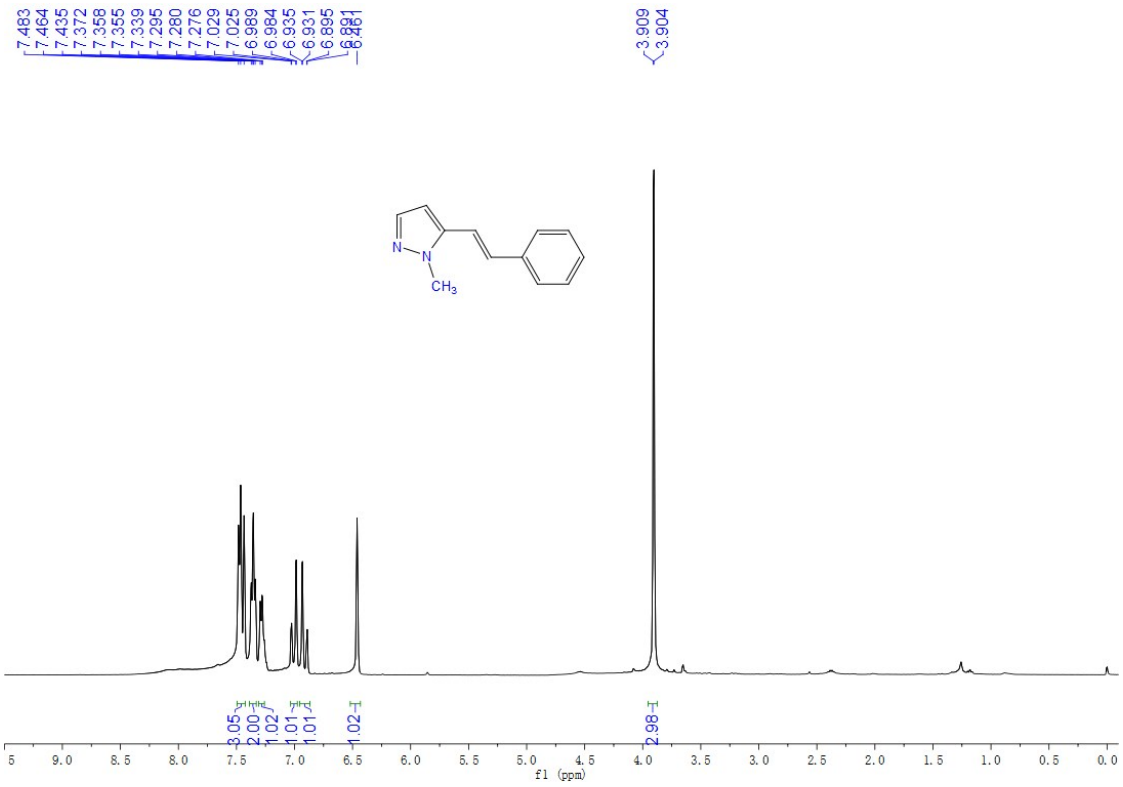

F
f1 (ppm)

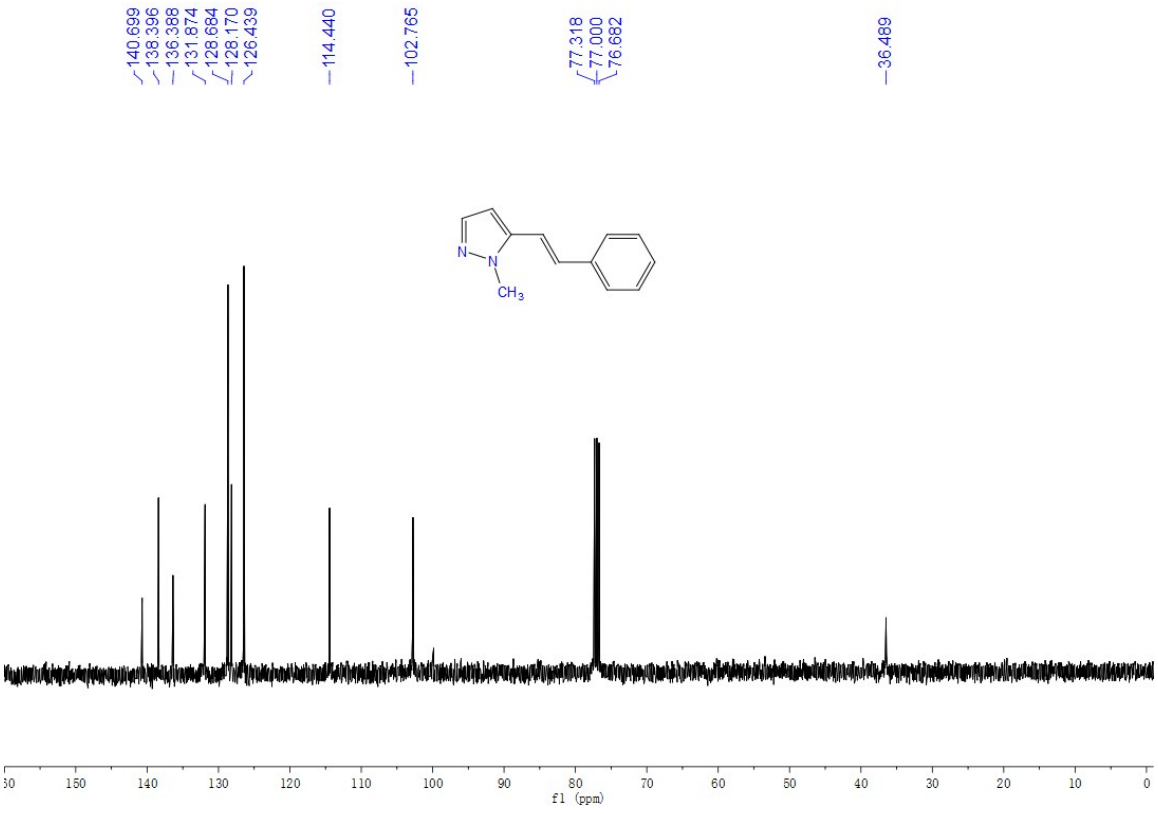

7.470
7.449
7.082
7.041
6.942
6.923
6.902
6.677
6.402
3.838
H3C—O
O
CH3
O
CH3
2.02
1.08
3.04
2.00
1.03
9.02
f1 (ppm)

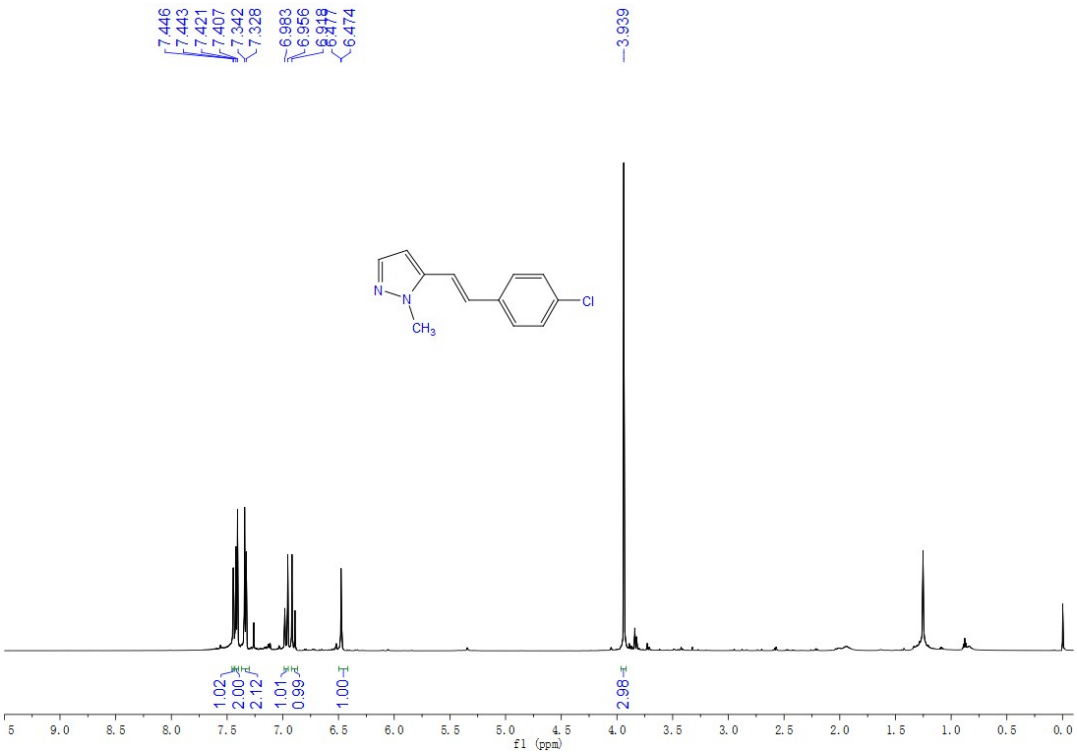

160.908
159.333
139.639
129.856
128.667
127.737
126.497
114.073
104.277
99.555
77.318
77.000
76.682
55.247
H3C—O
O
CH3
O
CH3
f1 (ppm)

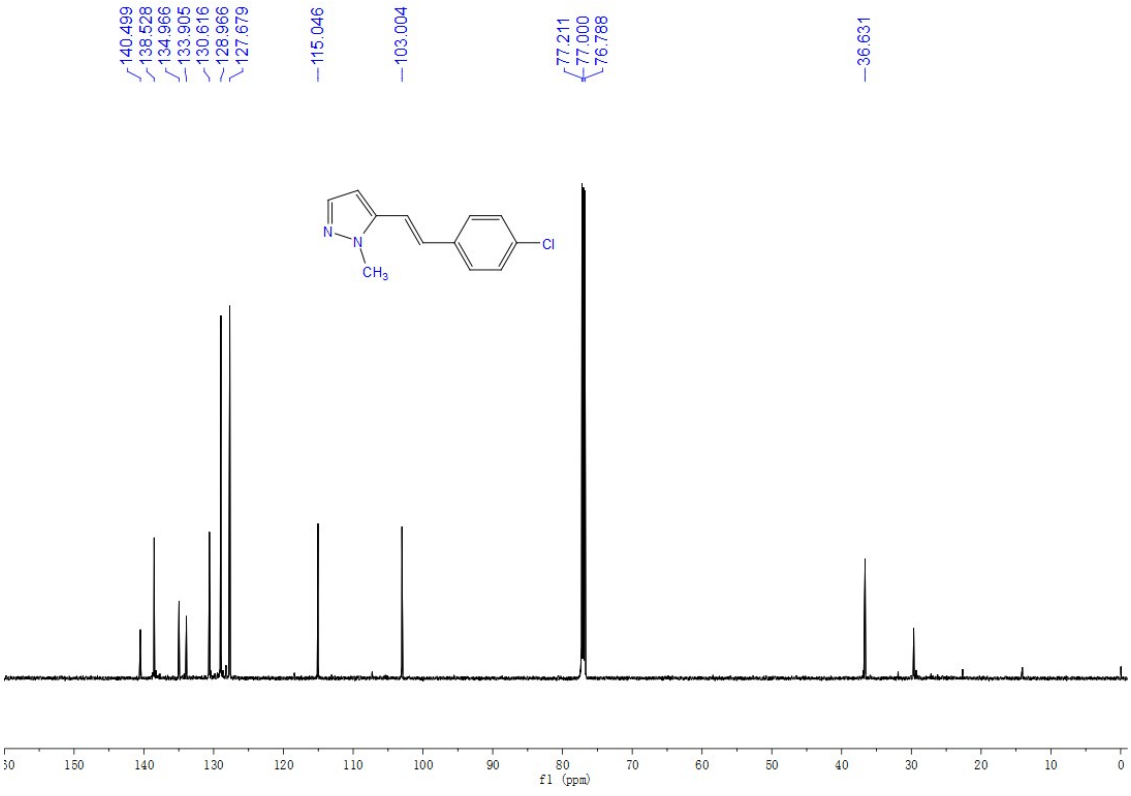

7.451
7.439
7.329
7.326
7.317
7.308
7.307
7.304
7.274
7.269
7.266
7.261
7.232
7.230
7.220
7.216
7.209
7.169
7.108
7.081
6.938
6.911
S
2.00
2.93
0.97
1.93
1.00
1.00
f1 (ppm)

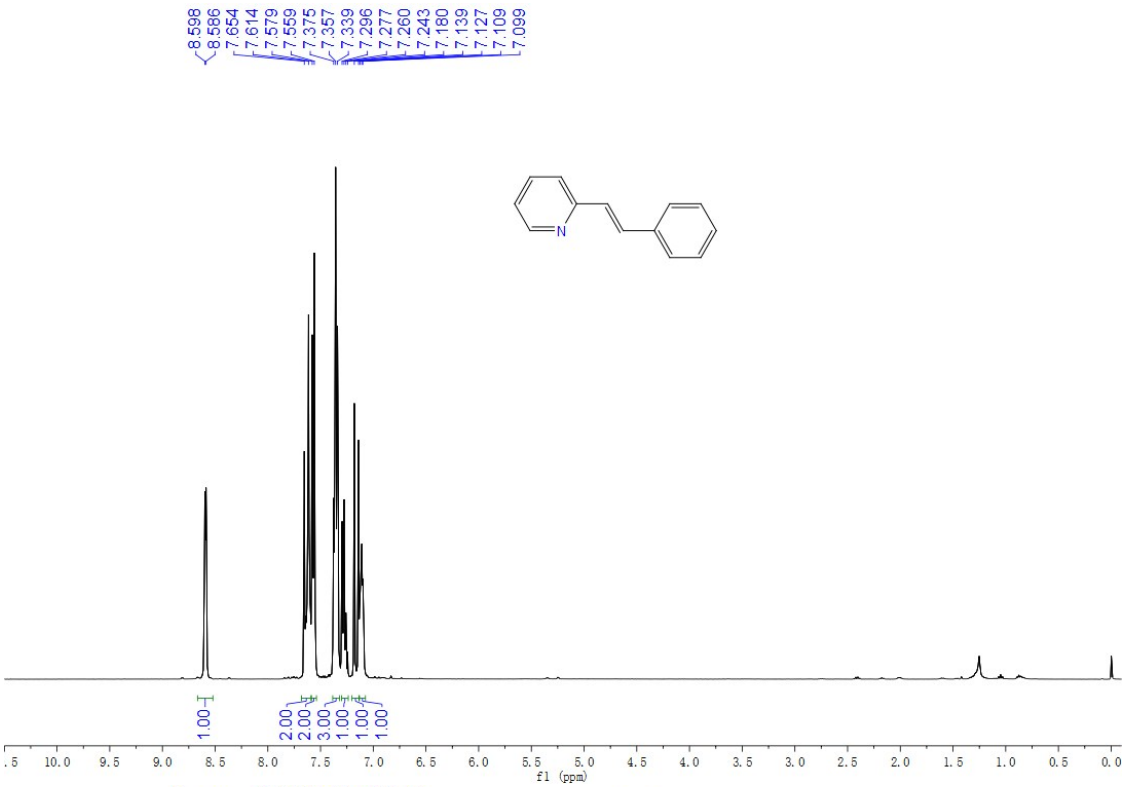

140.028
137.289
128.609
128.577
127.390
126.225
126.116
124.855
122.815
122.324
77.211
77.000
76.788
S
f1 (ppm)

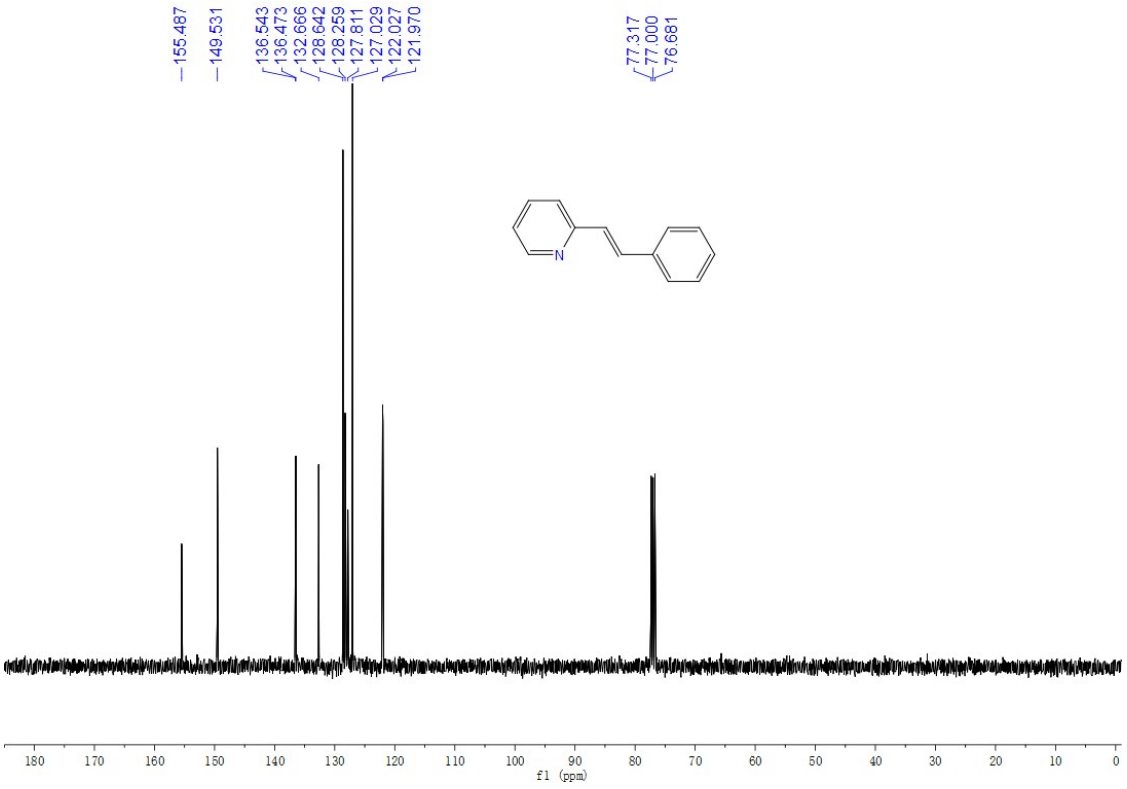

7.483
7.464
7.435
7.372
7.358
7.355
7.339
7.295
7.280
7.276
7.029
7.025
6.989
6.984
6.935
6.931
6.895
6.881
6.861
3.909
3.904
N
N
CH3
3.05
2.00
1.02
1.01
1.01
1.02
2.98
f1 (ppm)

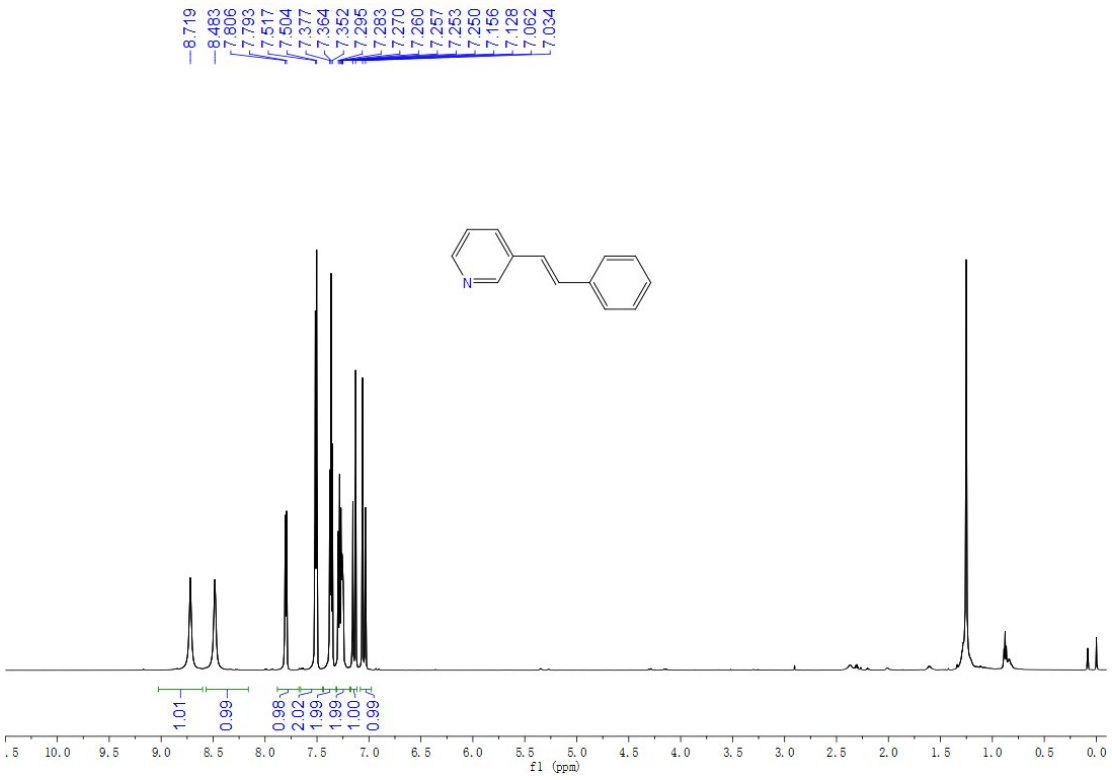

140.699
138.396
136.388
131.874
128.684
128.170
126.439
114.440
102.765
77.318
77.000
76.682
36.489
N
N
CH3
f1 (ppm)

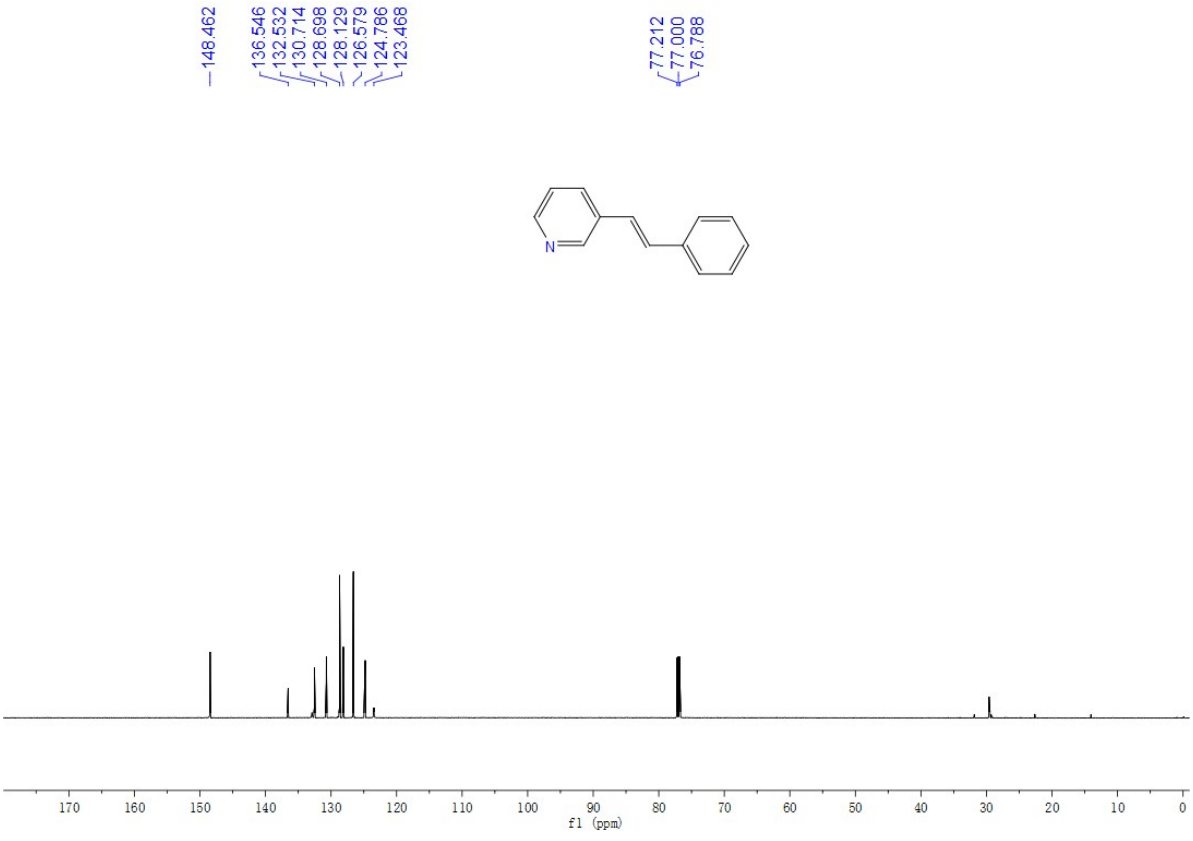

7.446
7.443
7.421
7.407
7.342
7.328
6.983
6.956
6.479
6.477
6.474
3.939
N
N
CH3
Cl
1.02
2.00
2.12
1.01
0.99
1.00
2.98
f1 (ppm)

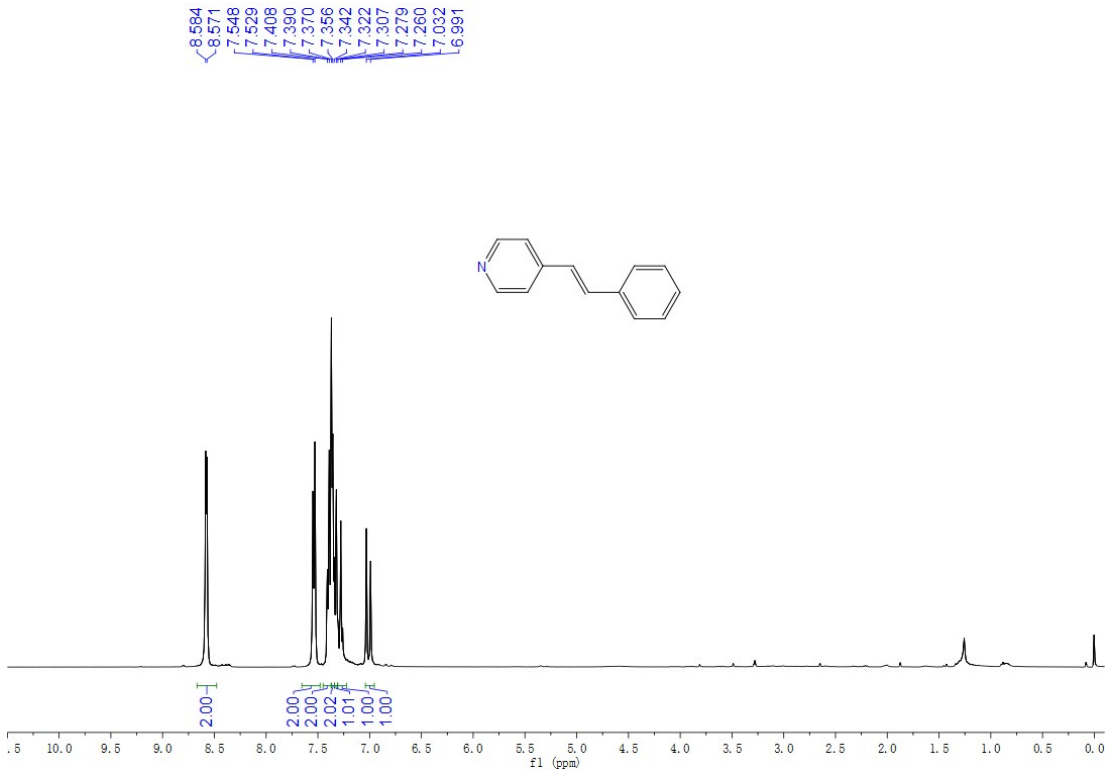

140.499
138.528
134.966
133.905
130.616
128.966
127.679
115.046
103.004
77.211
77.000
76.788
36.631
N
N
CH3
Cl
f1 (ppm)

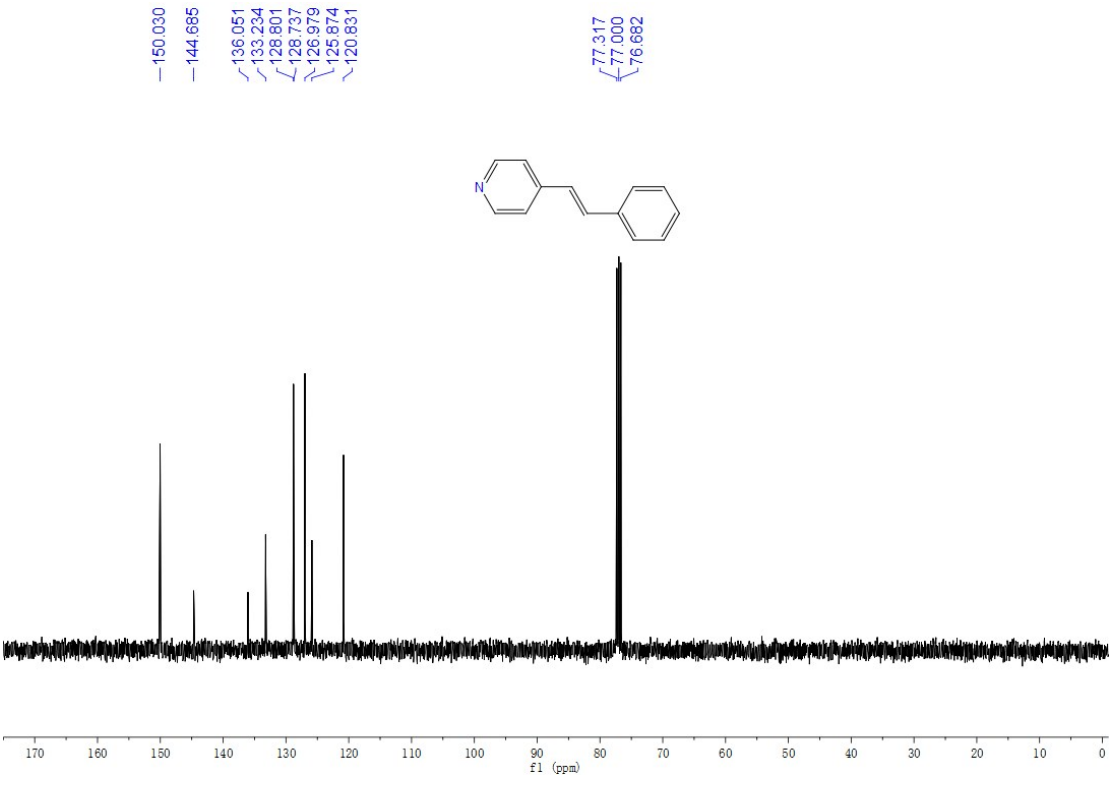

8.598
8.586
7.654
7.614
7.579
7.559
7.375
7.357
7.339
7.296
7.277
7.260
7.243
7.180
7.139
7.127
7.109
7.099
N
1.00
2.00
2.00
3.00
1.00
1.00
1.00
f1 (ppm)

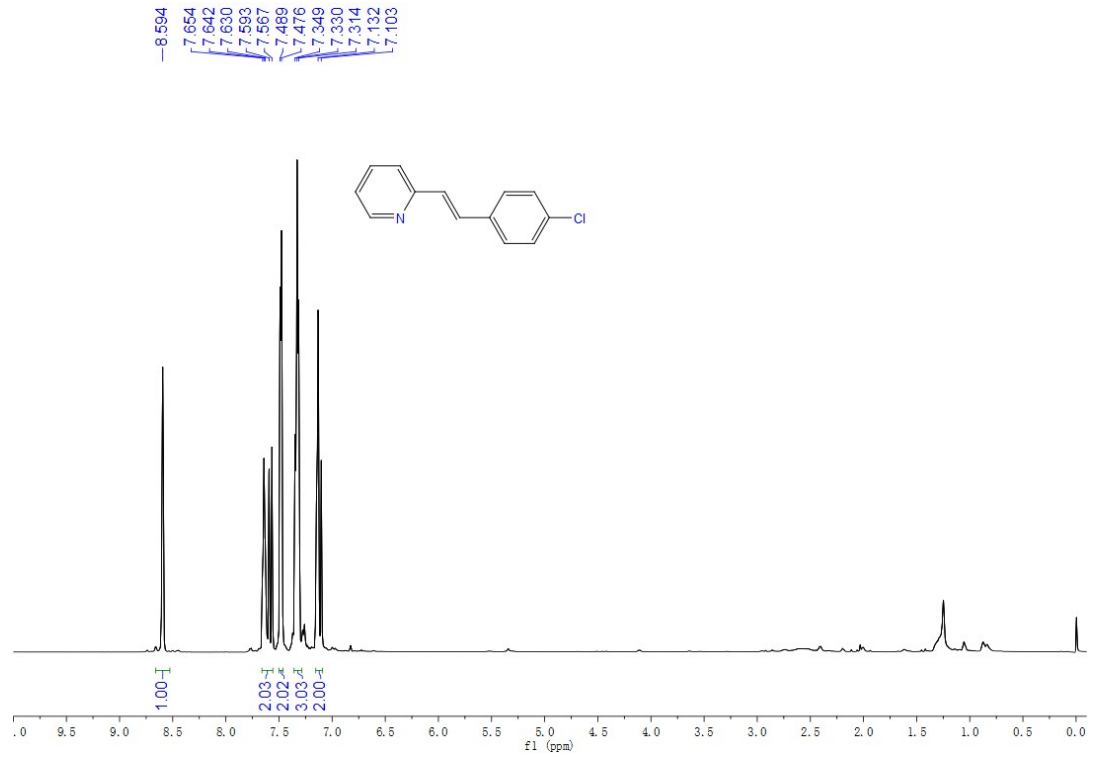

155.487
149.531
136.543
136.473
132.666
128.642
128.259
127.811
127.029
122.027
121.970
77.317
77.000
76.681
N
f1 (ppm)

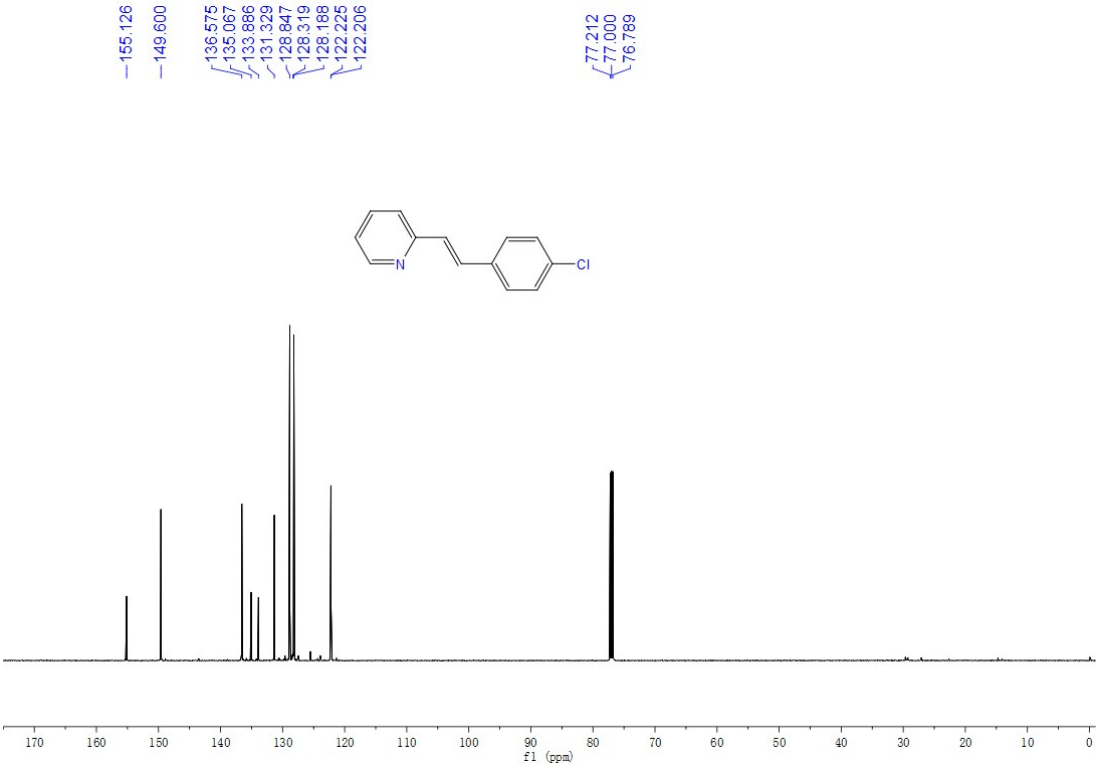

8.719
8.483
7.806
7.793
7.517
7.504
7.377
7.364
7.352
7.295
7.283
7.270
7.260
7.257
7.253
7.250
7.156
7.128
7.062
7.034
1.01
0.99
0.98
2.02
1.99
1.99
1.00
0.99
f1 (ppm)

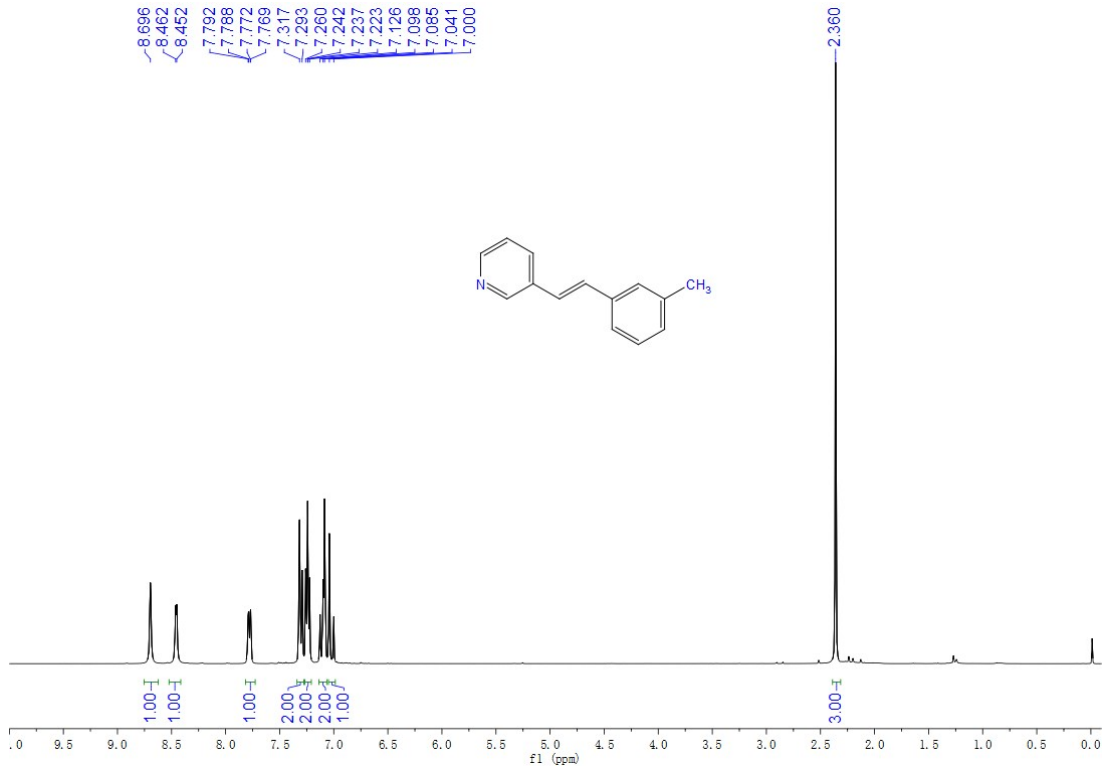

148.462
136.546
132.532
130.714
128.698
128.129
126.579
124.786
123.468
77.212
77.000
76.788
f1 (ppm)

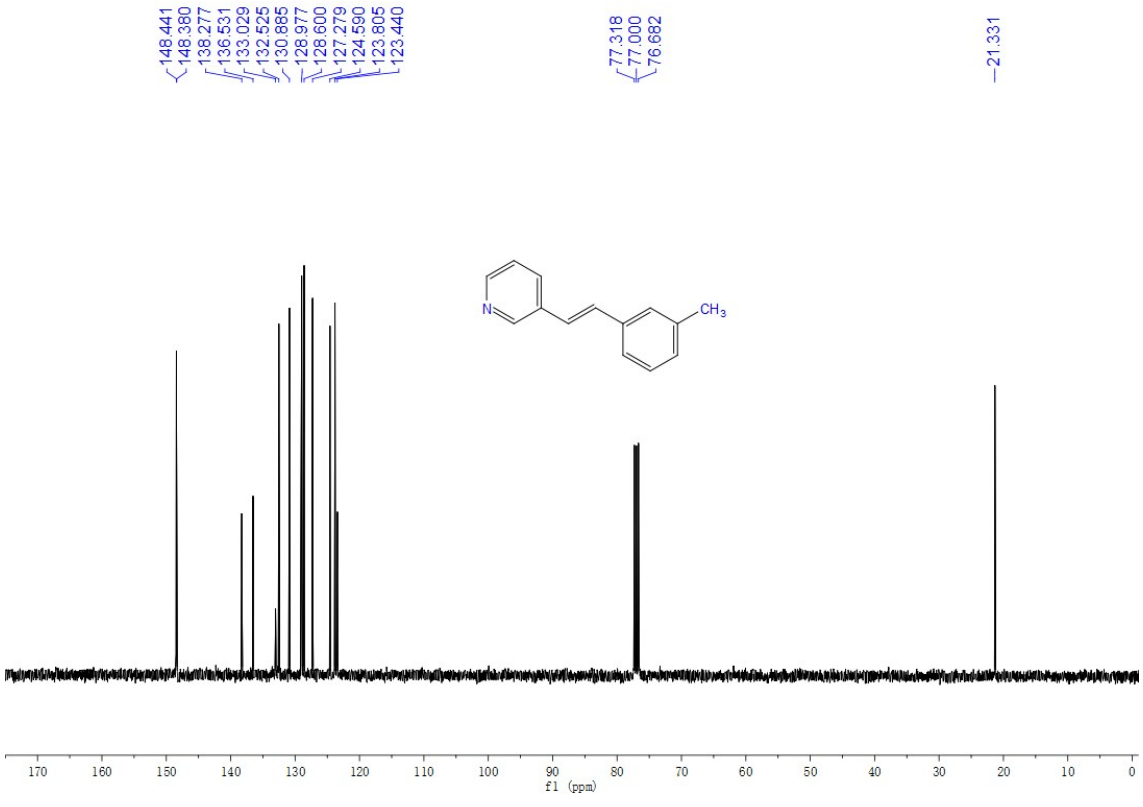

8.584
8.571
7.548
7.529
7.408
7.390
7.370
7.356
7.342
7.322
7.307
7.279
7.260
7.032
6.991
N
2.00
2.00
2.00
2.02
1.01
1.00
1.00
f1 (ppm)

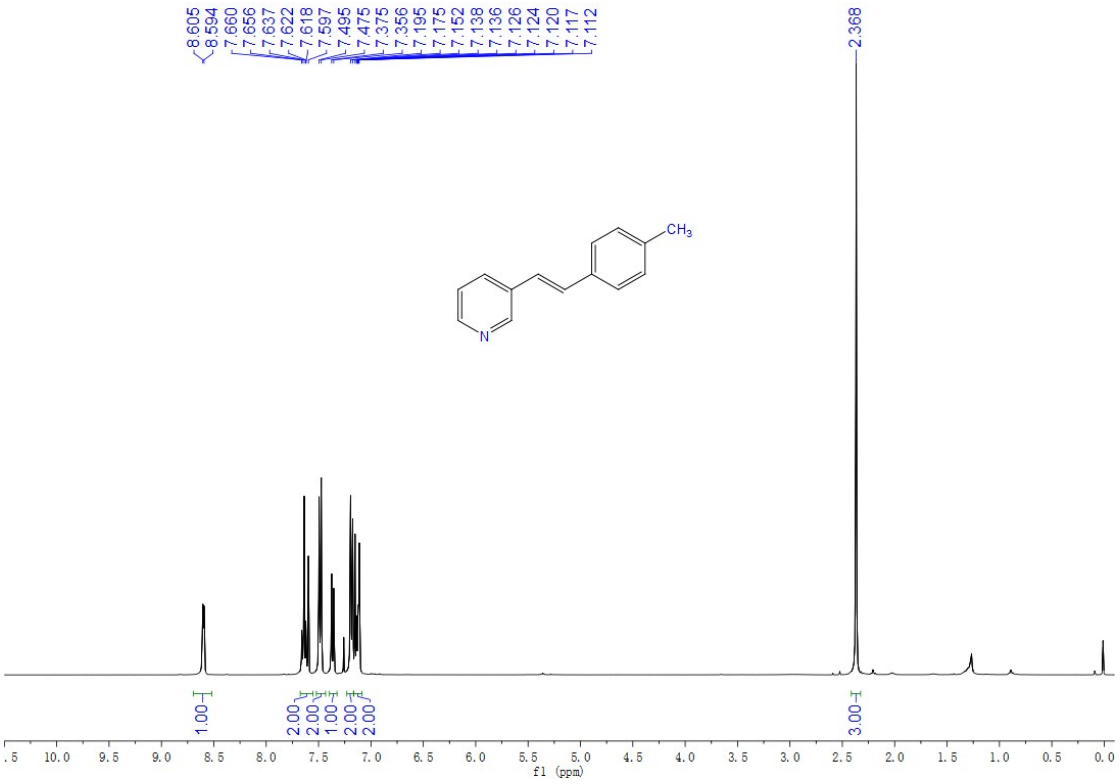

150.030
144.685
136.051
133.234
128.801
128.737
126.979
125.874
120.831
77.317
77.000
76.682
N
f1 (ppm)

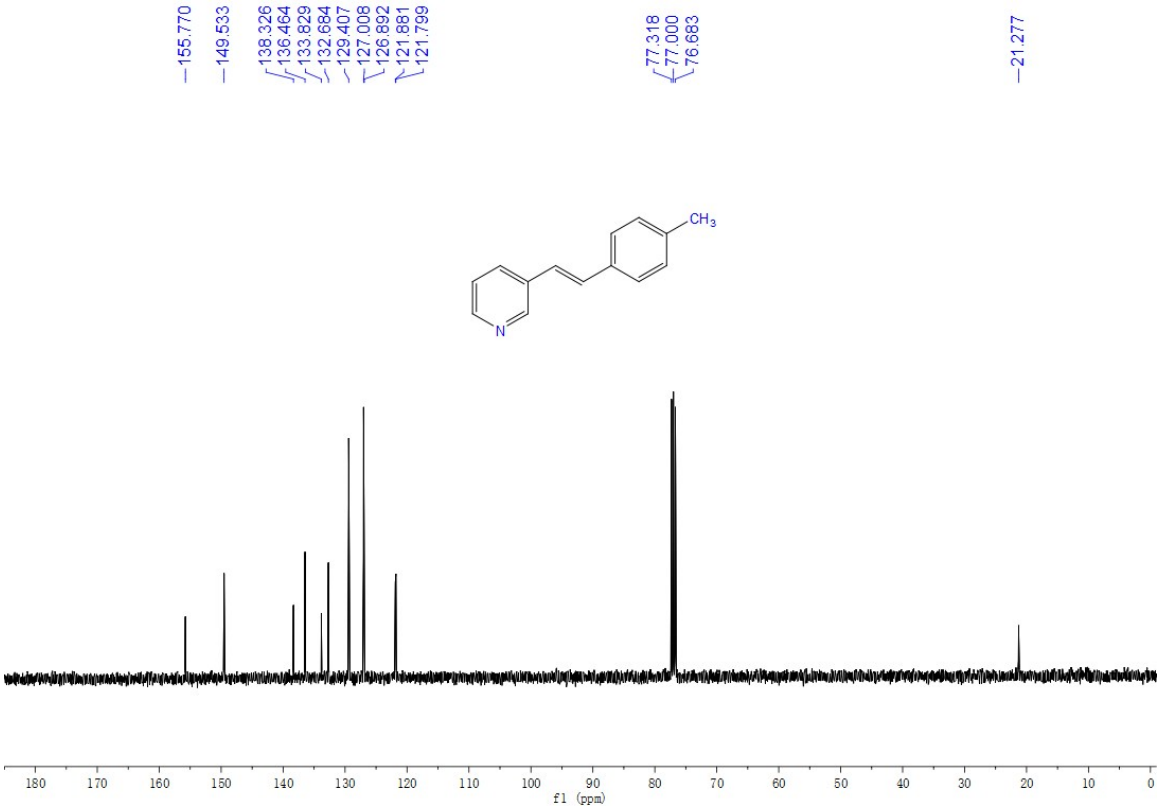

8.594
7.654
7.642
7.630
7.593
7.567
7.489
7.476
7.349
7.330
7.314
7.132
7.103
N
Cl
1.00
2.03
2.02
3.03
2.00
f1 (ppm)

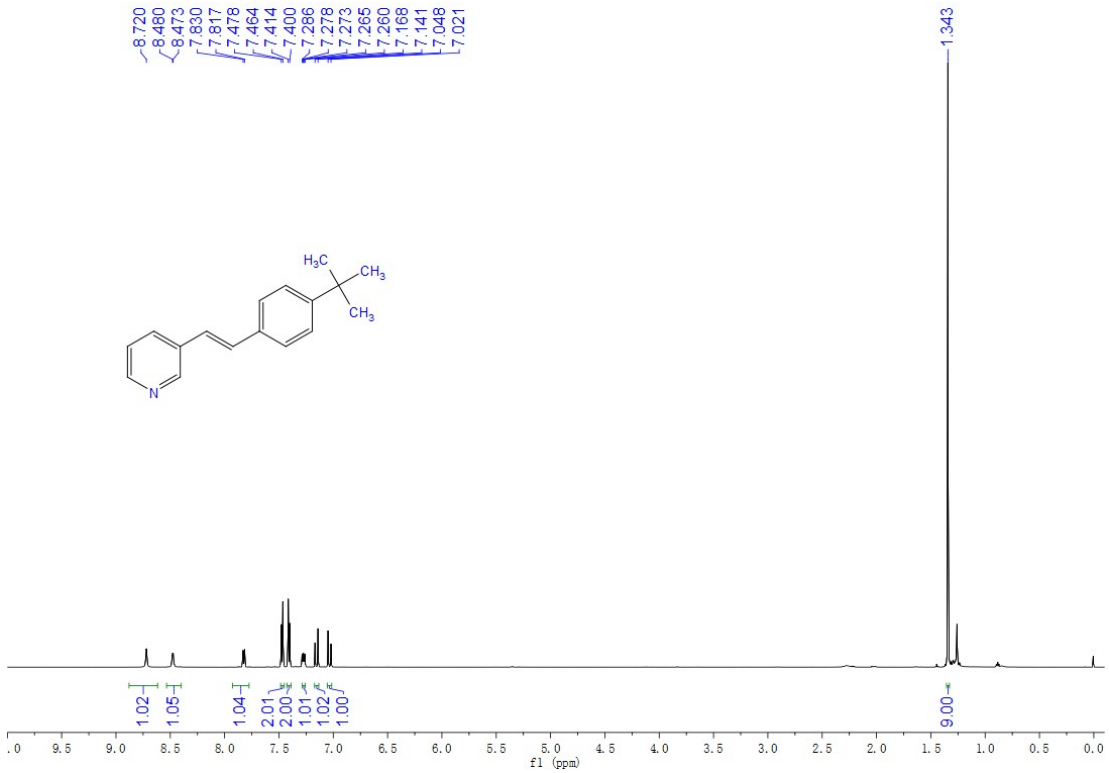

155.126
149.600
136.575
135.067
133.886
131.329
128.847
128.319
128.188
122.225
122.206
77.212
77.000
76.789
N
Cl
f1 (ppm)

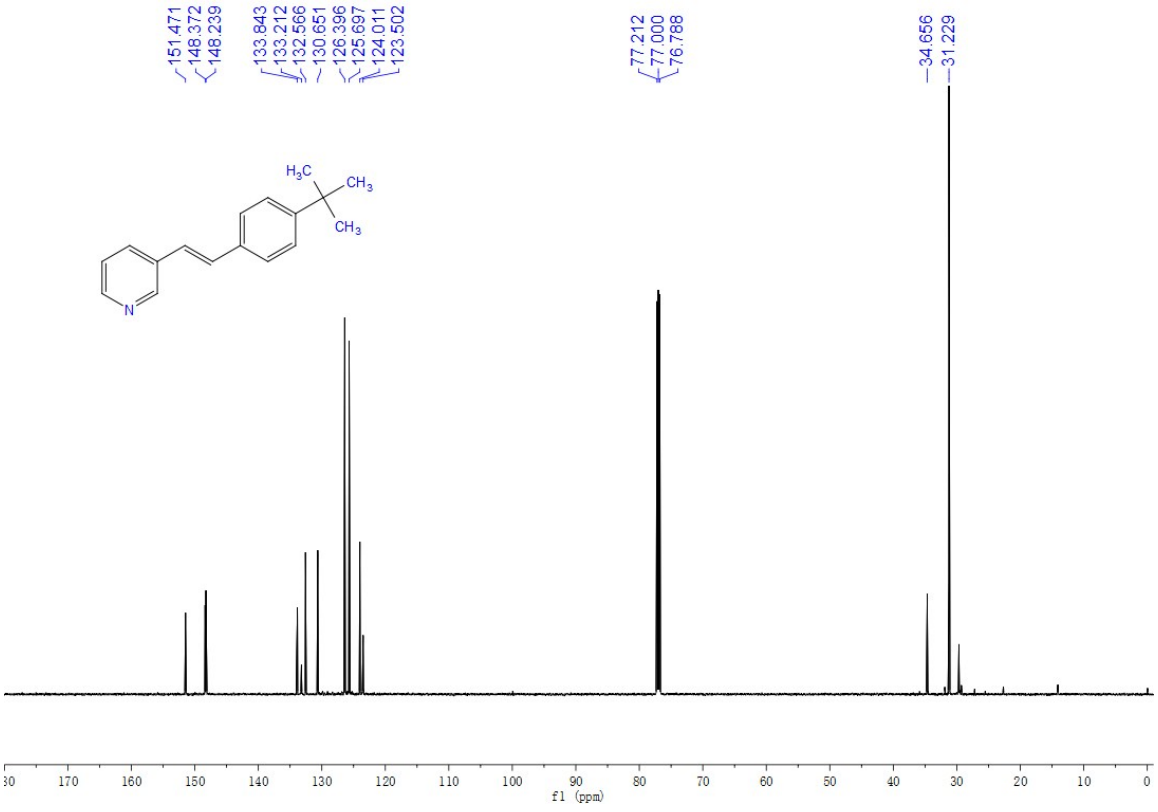

8.696
8.462
8.452
7.792
7.788
7.772
7.769
7.317
7.293
7.260
7.242
7.237
7.223
7.126
7.098
7.085
7.041
7.000
2.360
N
CH3
1.00
1.00
1.00
2.00
2.00
2.00
1.00
3.00
f1 (ppm)

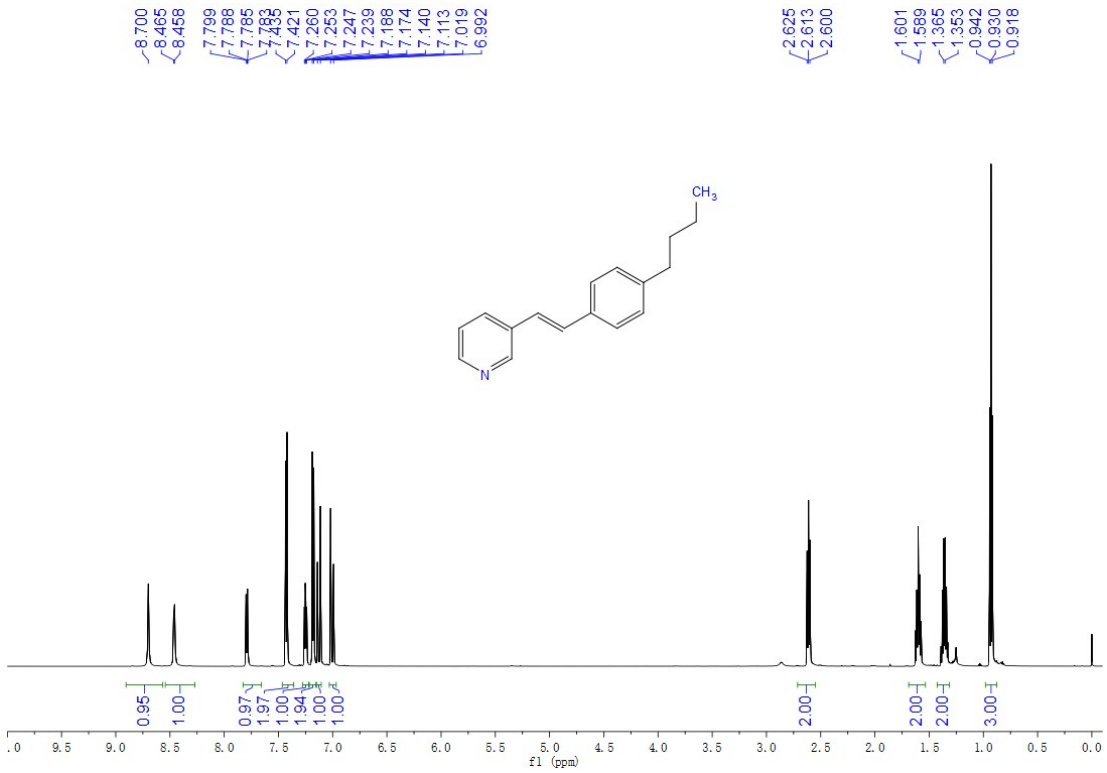

148.441
148.380
138.277
136.531
133.029
132.525
130.885
128.977
128.600
127.279
124.590
123.805
123.440
77.318
77.000
76.682
21.331
N
CH3
f1 (ppm)

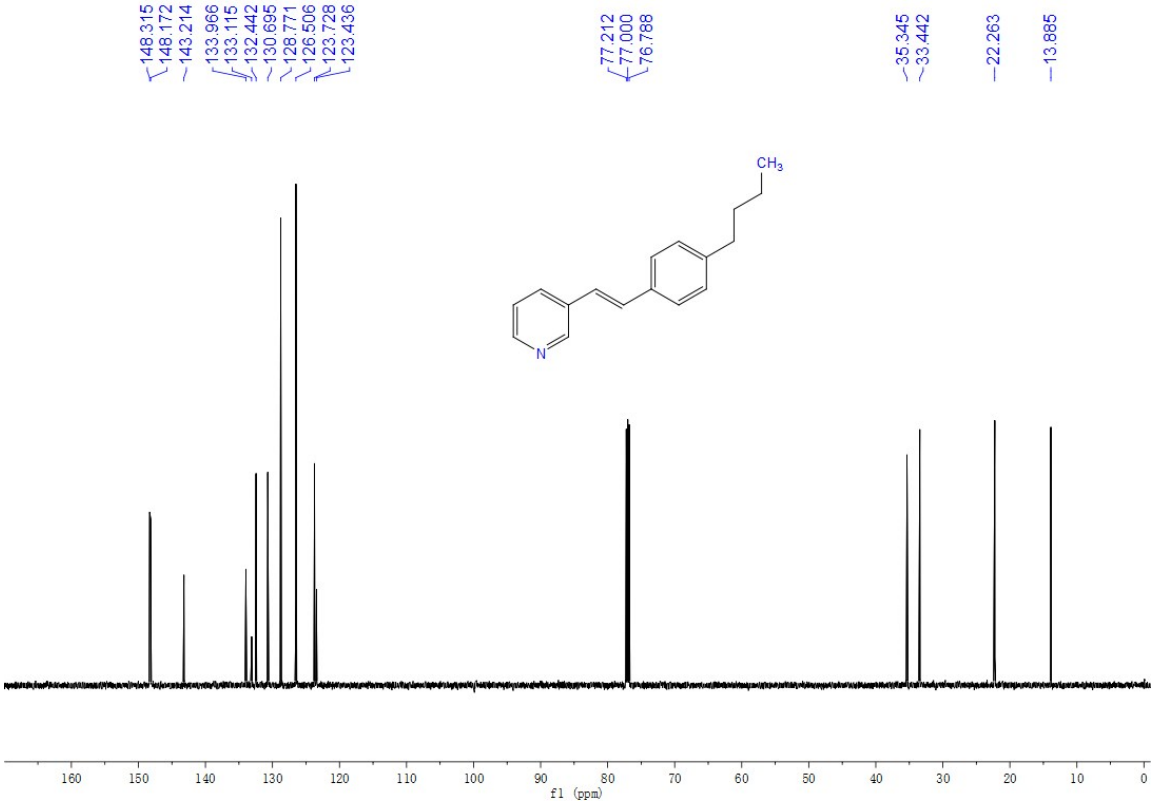

8.605
8.594
7.660
7.656
7.637
7.622
7.618
7.597
7.495
7.475
7.375
7.356
7.195
7.175
7.152
7.138
7.136
7.126
7.124
7.120
7.117
7.112
2.368
CH3
N
1.00
2.00
2.00
1.00
2.00
2.00
3.00
f1 (ppm)

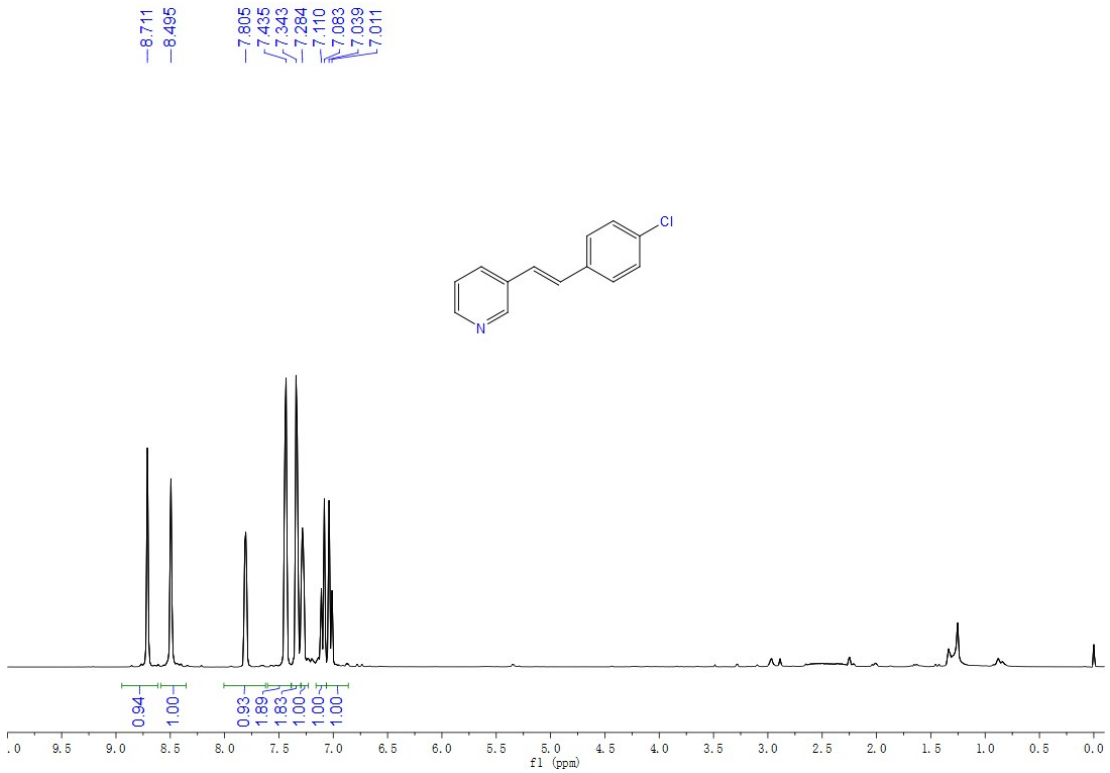

155.770
149.533
138.326
136.464
133.829
132.684
129.407
127.008
126.892
121.881
121.799
77.318
77.000
76.683
21.277
CH3
N
f1 (ppm)

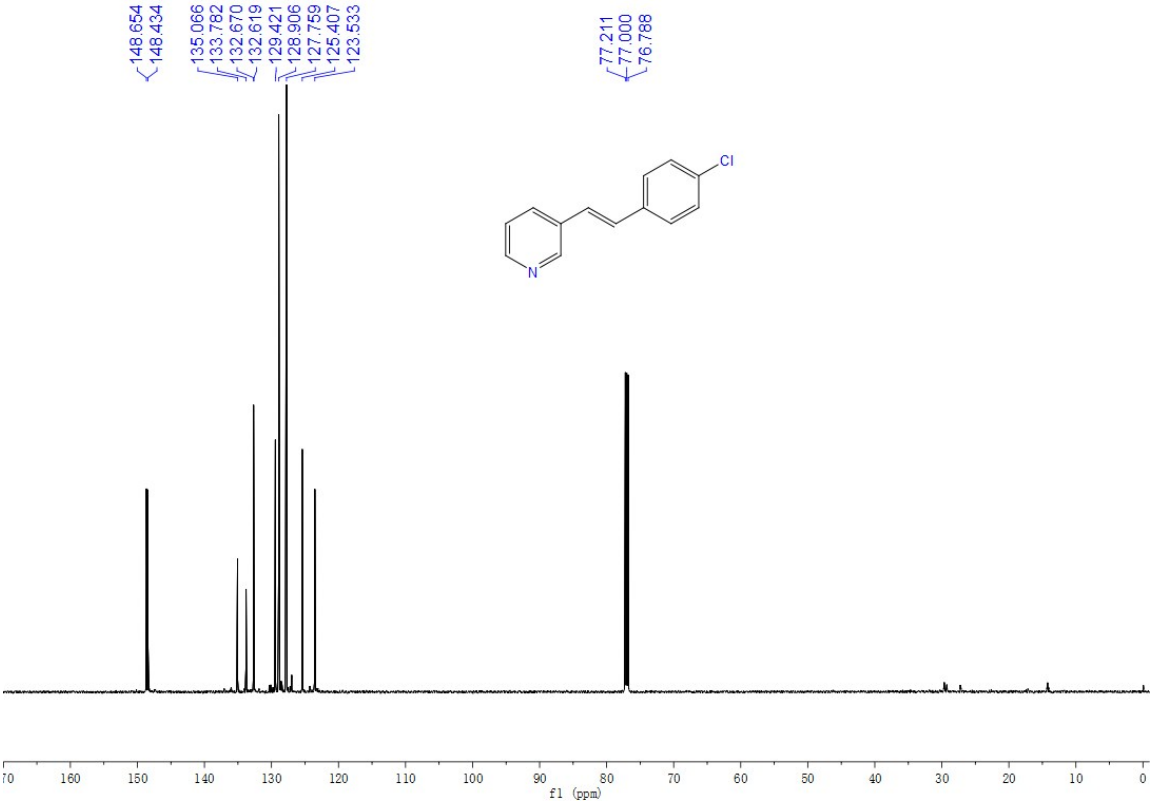

8.720
8.480
8.473
7.830
7.817
7.478
7.464
7.414
7.400
7.286
7.278
7.273
7.265
7.260
7.168
7.141
7.048
7.021
1.343
H3C
CH3
CH3
N
1.02
1.05
1.04
2.01
2.00
1.01
1.02
1.00
9.00
f1 (ppm)


151.471
148.372
148.239
133.843
133.212
132.566
130.651
126.396
125.697
124.011
123.502
77.212
77.000
76.788
34.656
31.229
H3C
CH3
CH3
N
f1 (ppm)

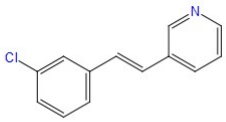

8.700
8.465
8.458
7.799
7.788
7.785
7.783
7.435
7.421
7.260
7.253
7.247
7.239
7.188
7.174
7.140
7.113
7.019
6.992
2.625
2.613
2.600
1.601
1.589
1.365
1.353
0.942
0.930
0.918
CH3
N
0.95
1.00
0.97
1.97
1.00
1.94
1.00
1.00
2.00
2.00
2.00
3.00
f1 (ppm)

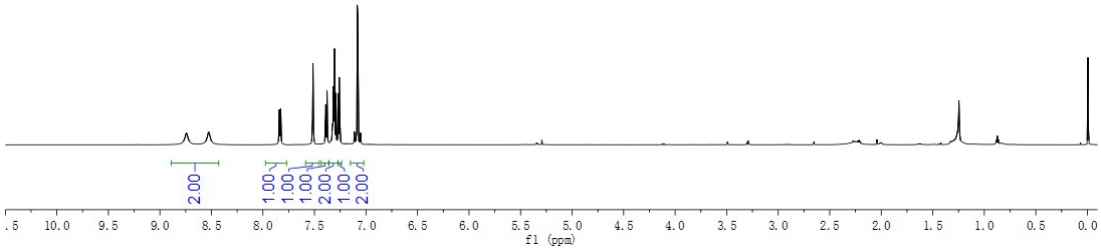

148.315
148.172
143.214
133.966
133.115
132.442
130.695
128.771
126.506
123.728
123.436
77.212
77.000
76.788
35.345
33.442
22.263
13.885
CH3
N
f1 (ppm)

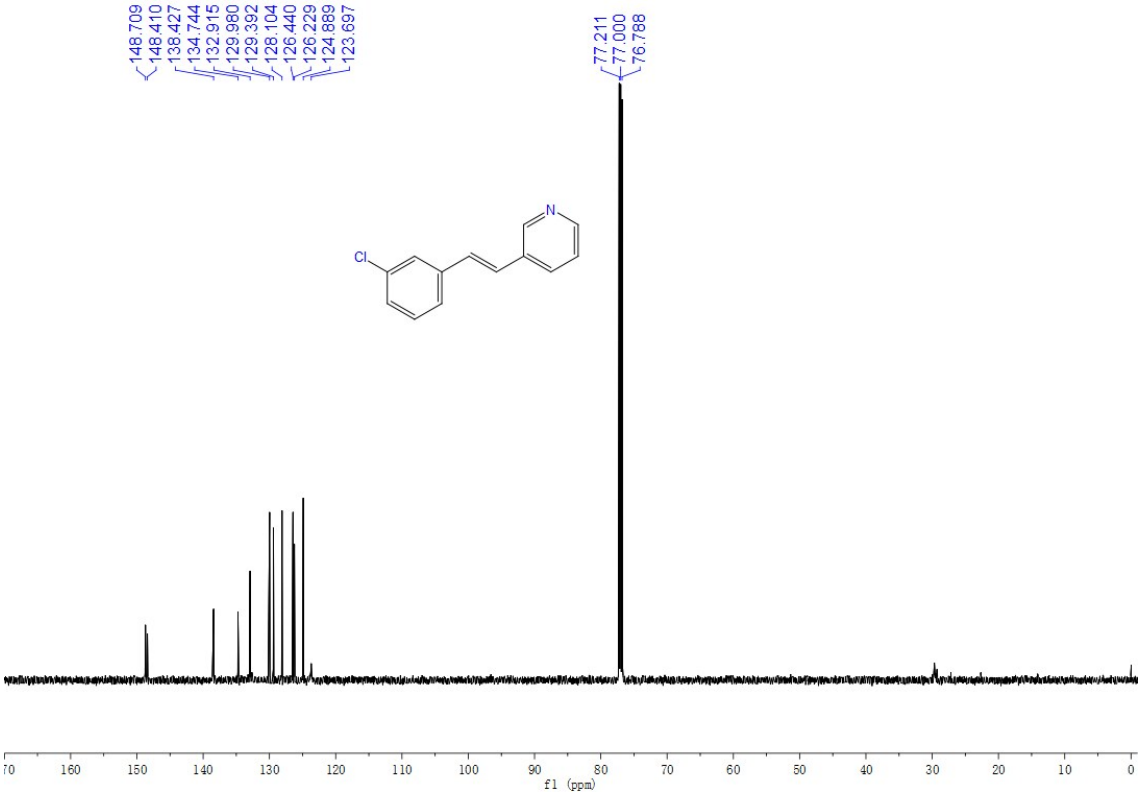

8.711
8.495
7.805
7.435
7.343
7.284
7.110
7.083
7.039
7.011
Cl
N
0.94
1.00
0.93
1.89
1.83
1.00
1.00
1.00
f1 (ppm)


148.654
148.434
135.066
133.782
132.670
132.619
129.421
128.906
127.759
125.407
123.533
77.211
77.000
76.788
Cl
N
f1 (ppm)

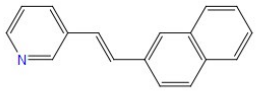

8.742
8.526
7.841
7.827
7.517
7.514
7.512
7.390
7.378
7.324
7.318
7.312
7.305
7.292
7.271
7.269
7.268
7.266
7.260
7.256
7.255
7.253
7.112
7.085
7.080
7.053

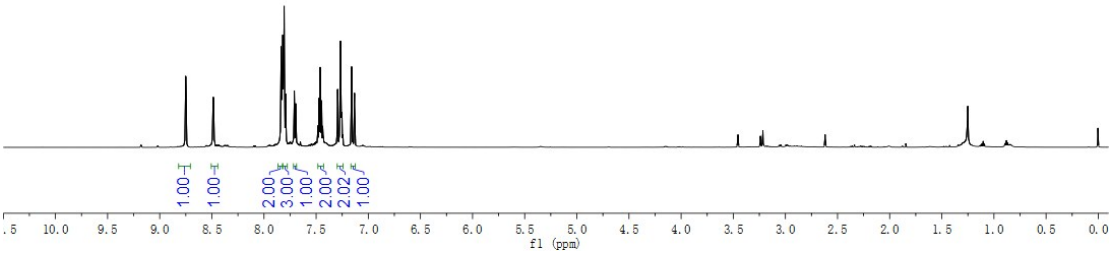

N
Cl


2.00
1.00
1.00
1.00
2.00
1.00
2.00
f1 (ppm)


148.709
148.410
138.427
134.744
132.915
129.980
129.392
128.104
126.440
126.229
124.889
123.697
77.211
77.000
76.788
N
Cl
f1 (ppm)

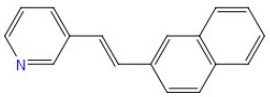

8.752
8.749
8.490
8.489
8.483
7.836
7.831
7.820
7.807
7.795
7.711
7.709
7.697
7.695
7.482
7.472
7.471
7.461
7.458
7.448
7.447
7.437
7.294
7.273
7.267
7.260
7.252
7.243
7.160
7.132


N


1.00
1.00
2.00
3.00
1.00
2.00
2.02
1.00
f1 (ppm)


148.415
148.405
134.009
133.511
133.181
132.955
132.593
130.799
128.386
128.015
127.646
127.072
126.405
126.166
125.013
123.493
123.209

77.211
77.000
76.788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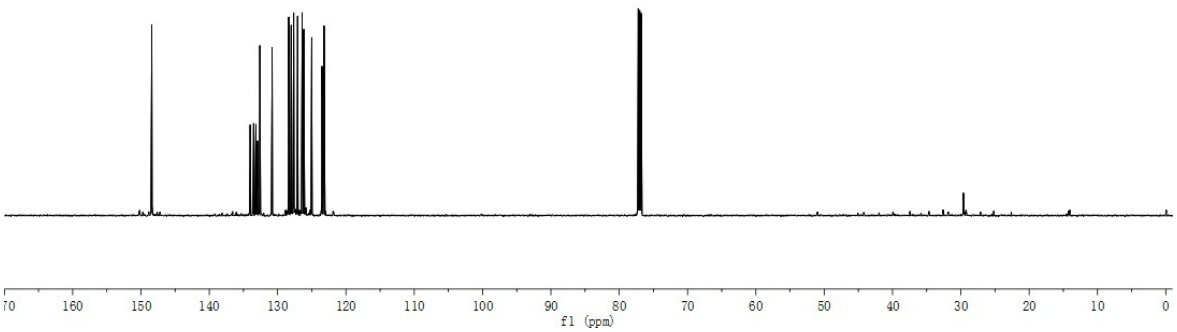
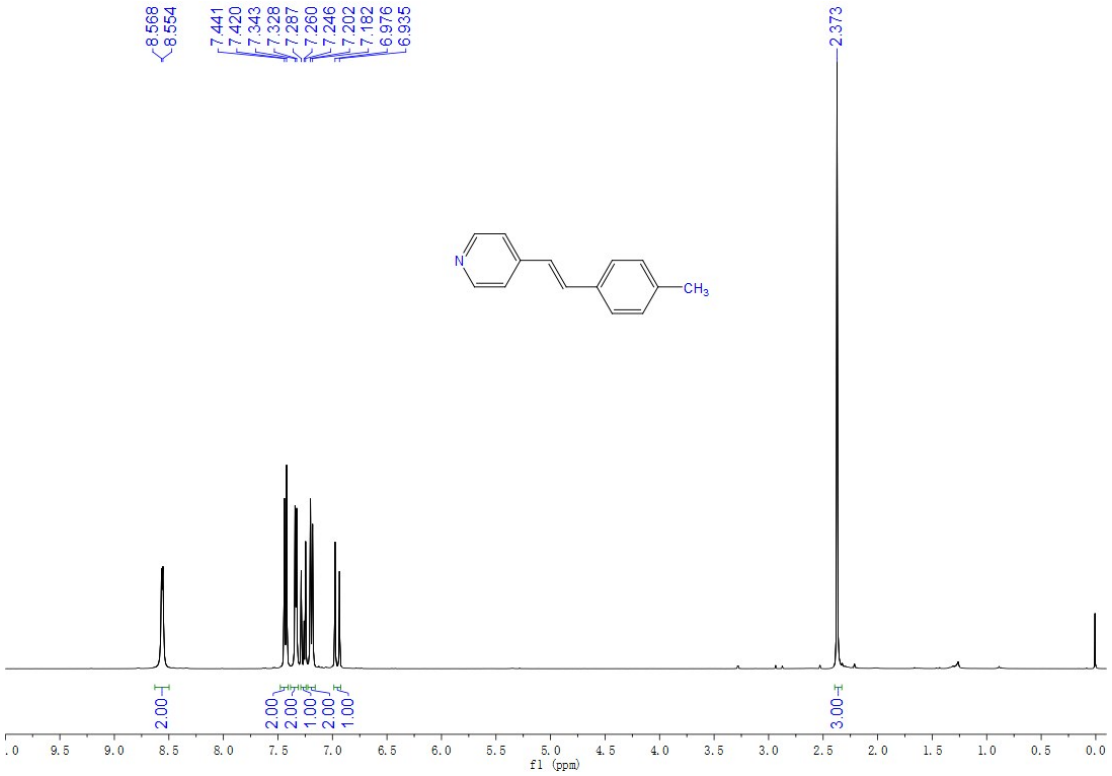
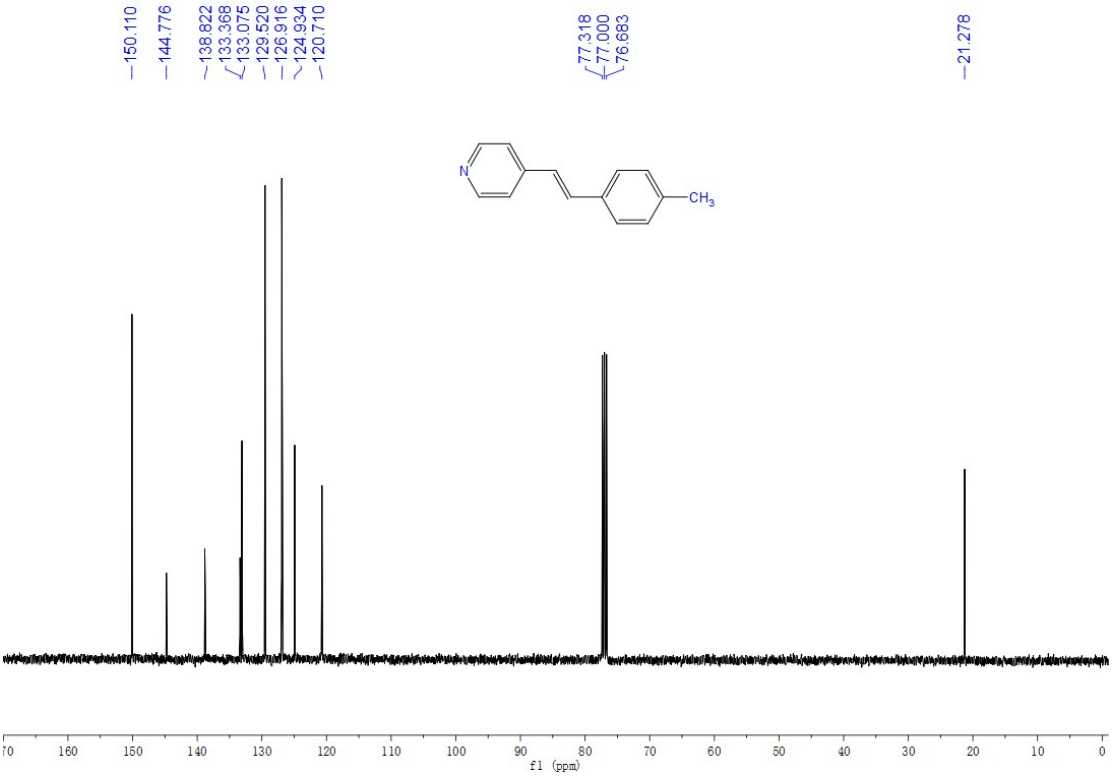
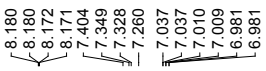
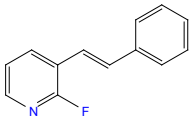
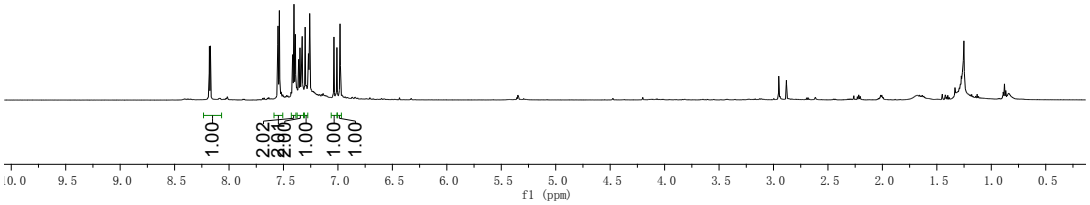

f1 (ppm)

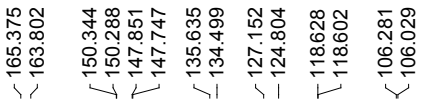

8.568
8.554
7.441
7.420
7.343
7.328
7.287
7.260
7.246
7.202
7.182
6.976
6.935
2.373
N
CH3
2.00
2.00
2.00
1.00
2.00
1.00
3.00
f1 (ppm)

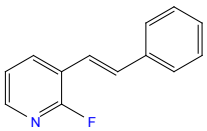

150.110
144.776
138.822
133.368
133.075
129.520
126.916
124.934
120.710
77.318
77.000
76.683
21.278
N
CH3
f1 (ppm)

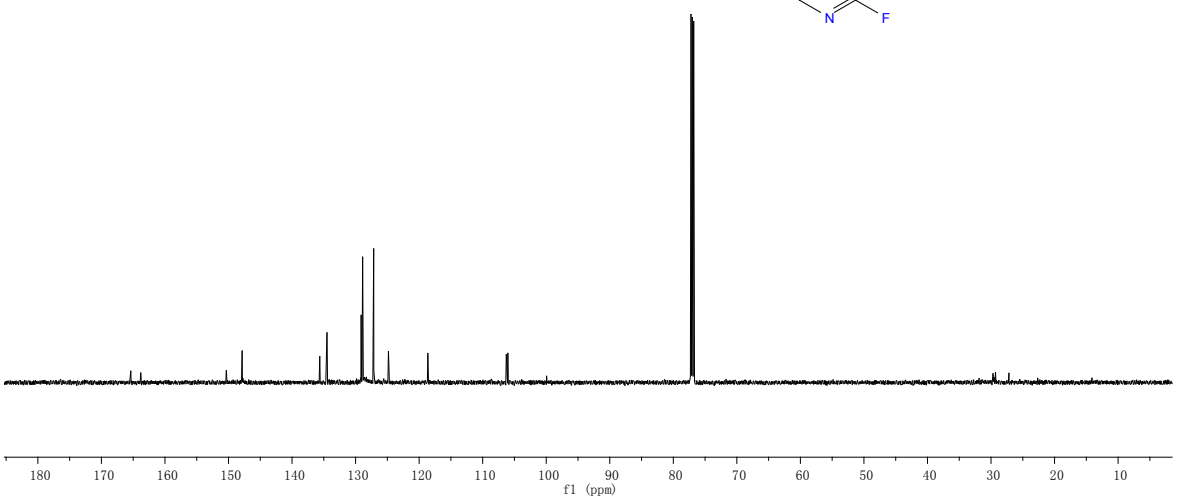

8.180
8.180
8.172
8.171
7.404
7.349
7.328
7.260
7.037
7.037
7.010
7.009
6.981
6.981

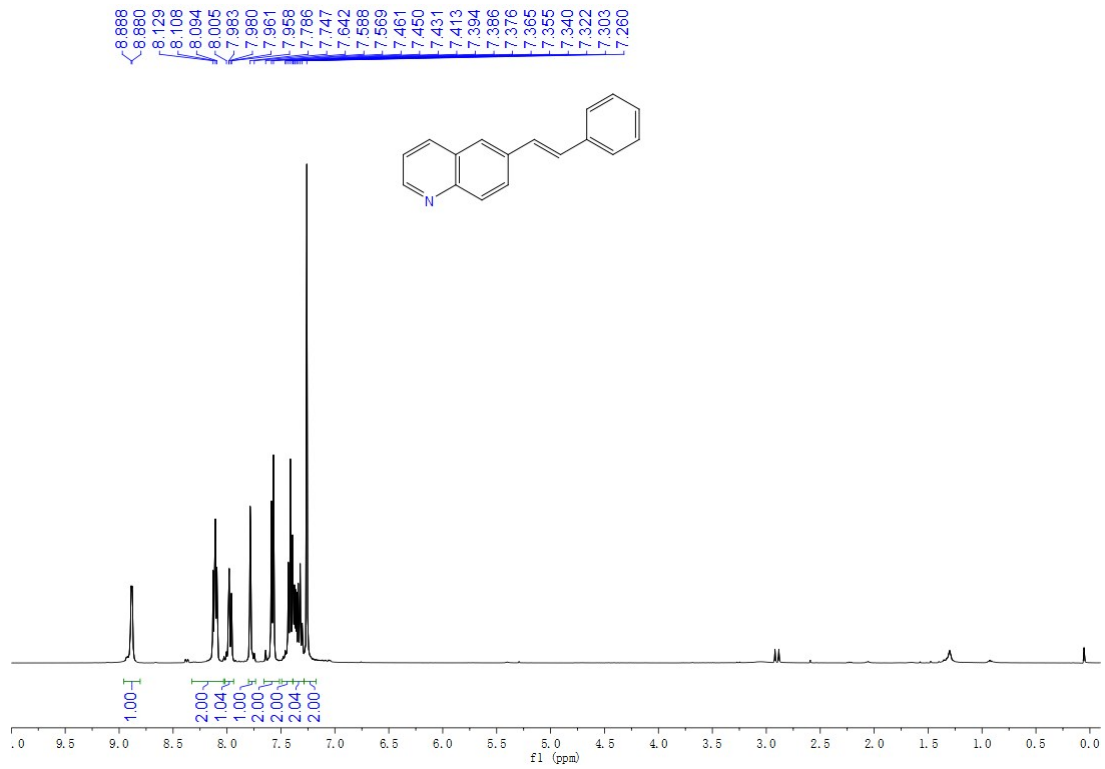

N
F

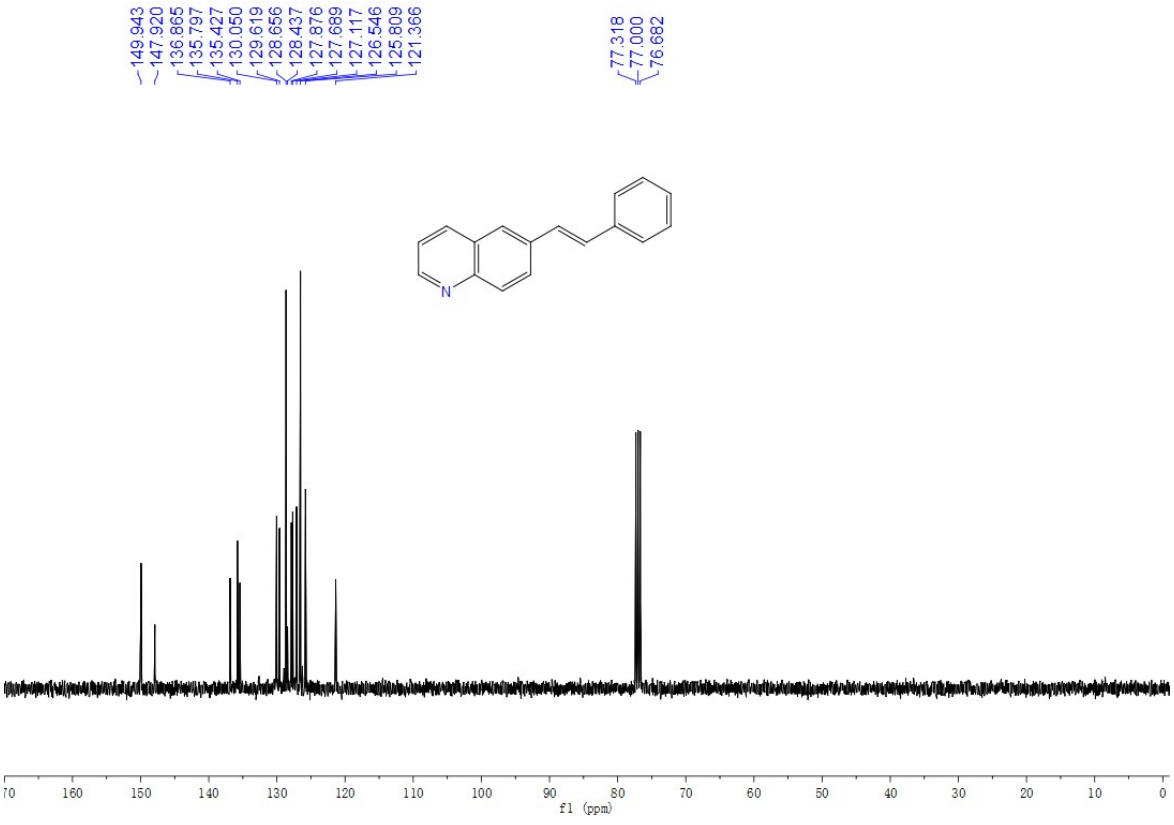

1.00
2.02
2.00
2.04
1.00
1.00
1.00
f1 (ppm)

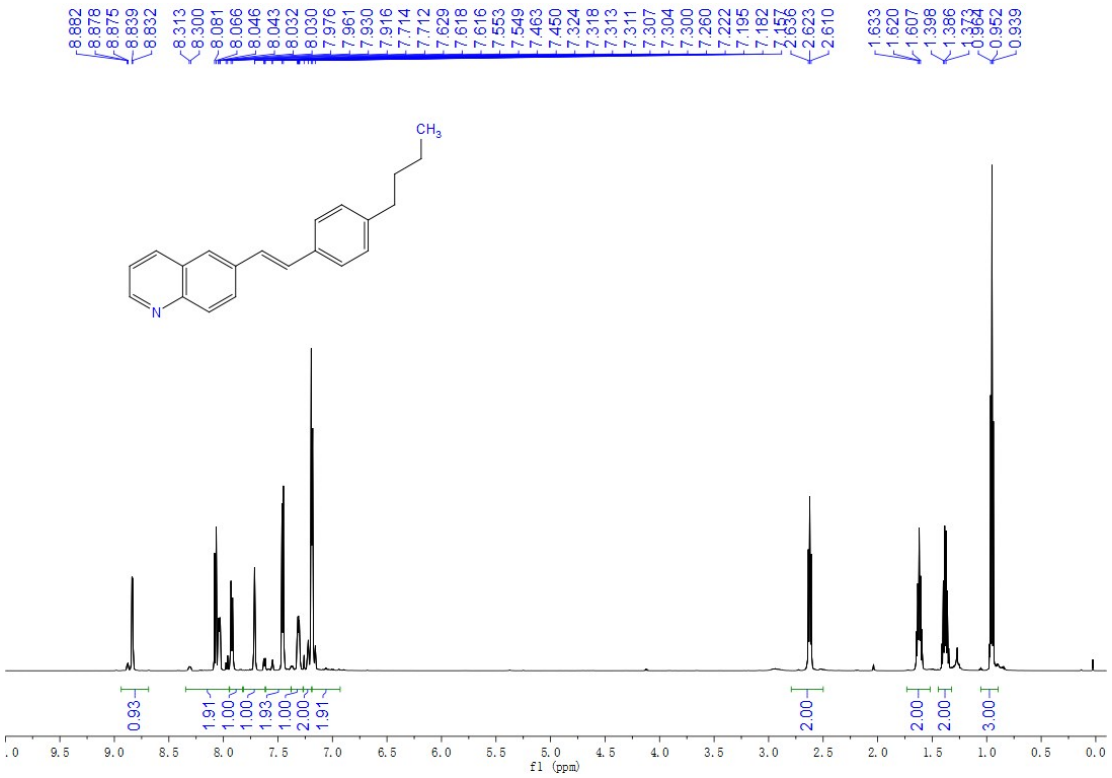

165.375
163.802
150.344
150.288
147.851
147.747
135.635
134.499
127.152
124.804
118.628
118.602
106.281
106.029
77.211
77.000
76.788

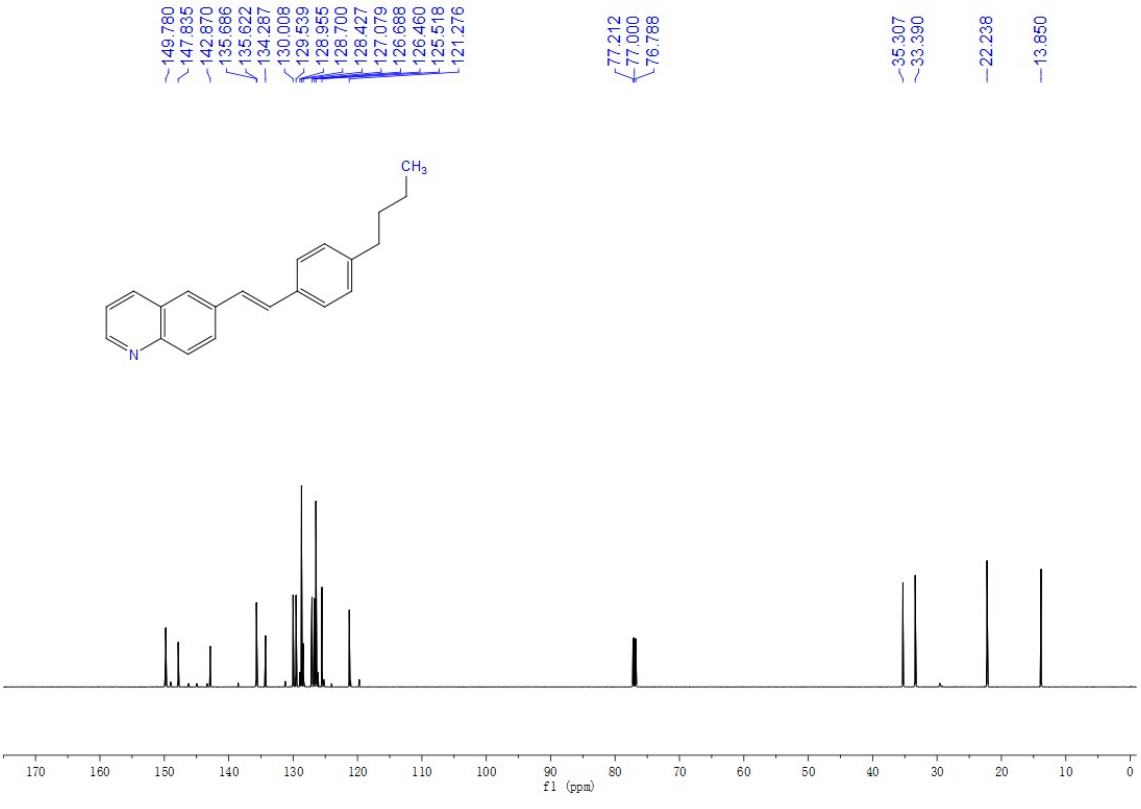

N
F


f1 (ppm)

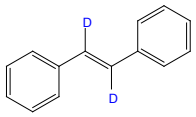

8.888
8.880
8.129
8.108
8.094
8.005
7.983
7.980
7.961
7.958
7.786
7.747
7.642
7.588
7.569
7.461
7.450
7.431
7.413
7.394
7.386
7.376
7.365
7.355
7.340
7.322
7.303
7.260
N
1.00
2.00
1.04
1.00
2.00
2.00
2.04
2.00
f1 (ppm)

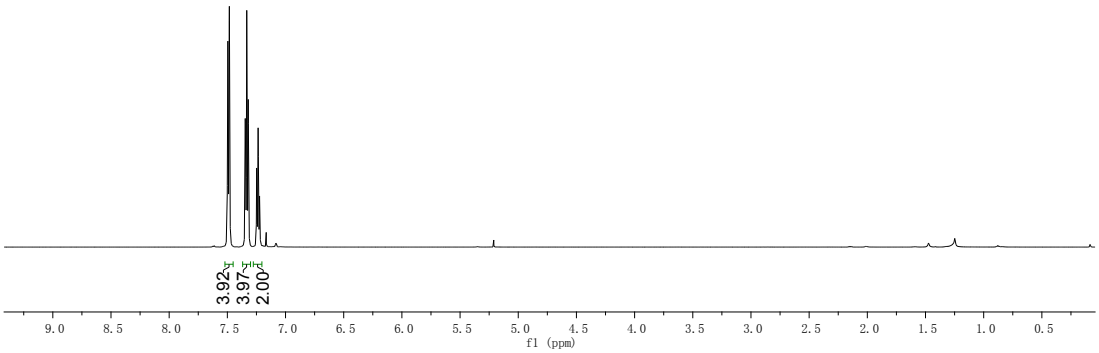

149.943
147.920
136.865
135.797
135.427
130.050
129.619
128.656
128.437
127.876
127.689
127.117
126.546
125.809
121.366
77.318
77.000
76.682
N
f1 (ppm)


8.882
8.878
8.875
8.839
8.832
8.313
8.300
8.081
8.066
8.046
8.043
8.032
8.030
7.976
7.961
7.930
7.916
7.714
7.712
7.629
7.618
7.616
7.553
7.549
7.463
7.450
7.324
7.318
7.313
7.311
7.307
7.304
7.300
7.260
7.222
7.195
7.182
7.157
7.136
2.623
2.610
1.633
1.620
1.607
1.398
1.386
1.373
0.964
0.952
0.939
CH3
N
0.93
1.91
1.00
1.00
1.93
1.00
2.00
1.91
2.00
2.00
2.00
3.00
f1 (ppm)

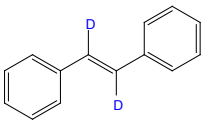

149.780
147.835
142.870
135.686
135.622
134.287
130.008
129.539
128.955
128.700
128.427
127.079
126.688
126.460
125.518
121.276
77.212
77.000
76.788
35.307
33.390
22.238
13.850
CH3
N
f1 (ppm)


7.498
7.496
7.484
7.483
7.346
7.333
7.320
7.248
7.246
7.236
7.223

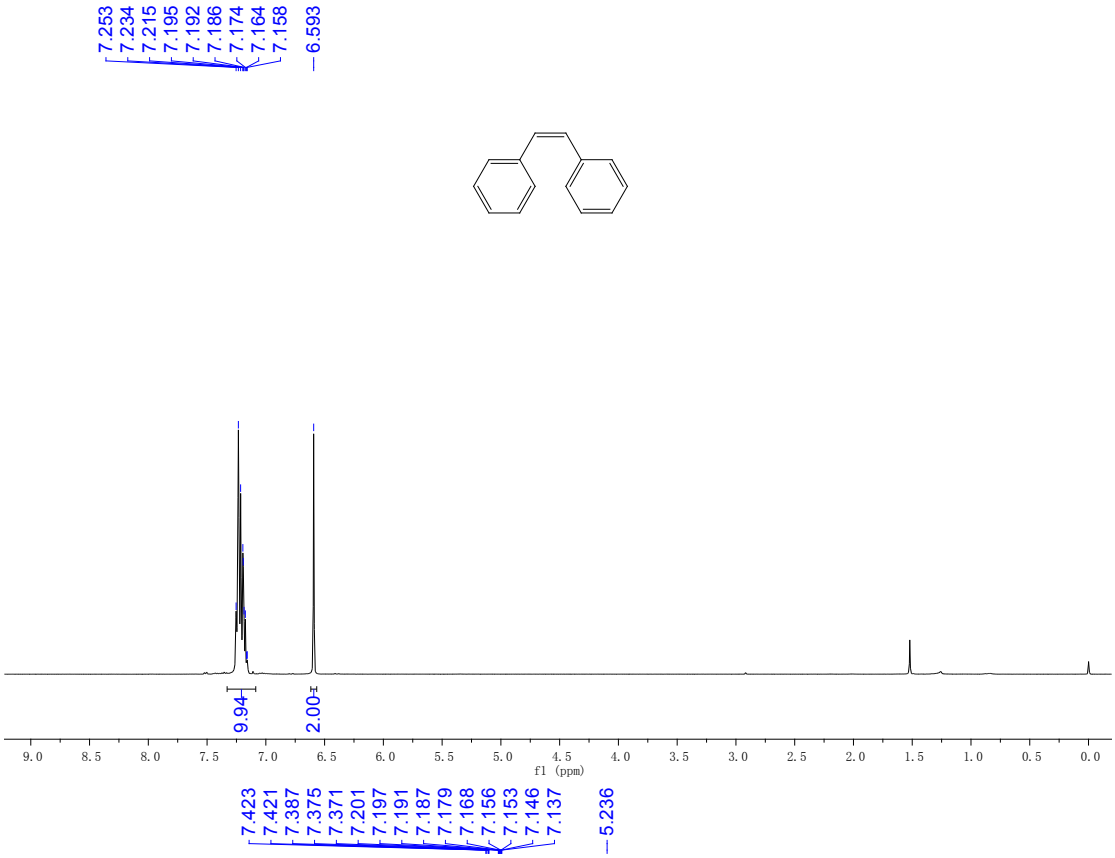

D
D

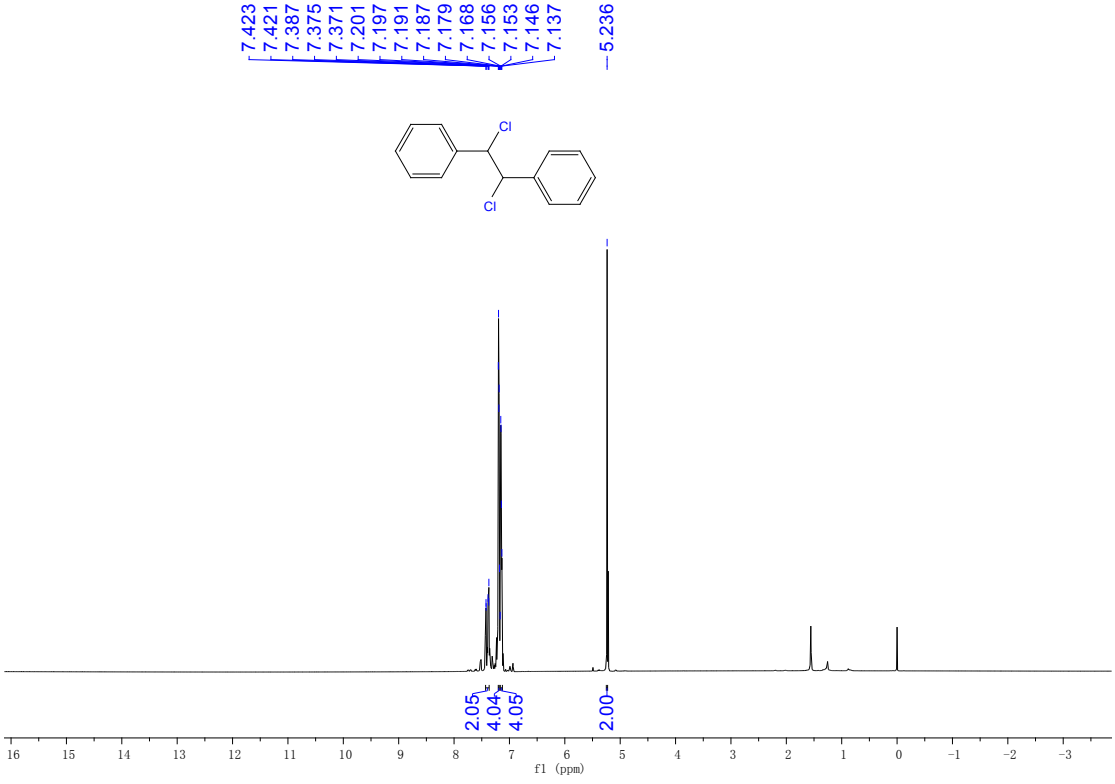

3.92
3.97
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


137.173
128.633
127.558
126.445
77.212
77.000
76.788


D
D

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.253
7.234
7.215
7.195
7.192
7.186
7.174
7.164
7.158
6.593
9.94
2.00
f1 (ppm)


7.423
7.421
7.387
7.375
7.371
7.201
7.197
7.191
7.187
7.179
7.168
7.156
7.153
7.146
7.137
5.236
Cl
Cl
2.05
4.04
4.05
2.00
f1 (ppm)